Records
of
The Geological Survey
of India

VOL - 17
1884

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1] 1884 [February

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA, AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1883

HUNDES
Mr Griesbach

The extra Peninsula area —Of work done during the past season, Mr Griesbach's would be popularly considered the most interesting, as dealing with the main Himalayan range and the well-known formations there displayed on so grand a scale Unfortunately no matured abstract of his observations is yet available, as Mr Griesbach had to make all haste from Tibet late in October to join the expedition to the Takht-i-Suleiman, and he is still engaged on the north-west frontier He had however brought his particular undertaking to its intended conclusion, having completed the survey of the Hundes basin to its western limit on the flanks of the gneissic mass of Purgial mountain which separates Hundes from Spiti The obstruction encountered from the unruly condition of the people on both sides of the frontier was even greater than in previous seasons, we must only accept this sketch survey as all that is possible in that direction for some time to come It is further very satisfactory that Mr Griesbach has been able to link his work with that of Dr Stoliczka in his typical sections of Spiti by a trip over the Bhabeh and Manirang passes For some important horizons he has satisfied himself of the identity of the sections in Spiti and Hundes, particularly the occurrence in Spiti of full representatives of the lower triassic groups, not noticed by Stoliczka We have thus strong evidence for the presumption already made that the present separation of these basins is largely, if not altogether, a feature of disturbance, an example on the largest scale of the longitudinal waving of the lines of elevation which has been frequently noticed in the detailed structure of these mountains

THE TAKHT I SULEIMAN

The Takht-i-Suleiman, Mr Griesbach writes, consists of the cretaceous sandstones with limestones recently described by Mr Blanford (Memoirs, Vol XX, pt. 2), as forming the crest of the range 80 miles to the south

JAUNSAR
Mr. Oldham

We have at last got a bit of critical study from that most obscure region, the Lower Himalaya, in Mr Oldham's work of last season in Jaunsár (Records, Vol XVI, pt 4) This remark leaves out of count Mr Mallet's very thorough study from the same region, in Sikkim (Memoirs, Vol XI, 1874), the distance is so great (700 miles), and the details so different, also Colonel McMahon's most excellent observations in the Simla area (Records, Vol X, pt 4, 1877), on the grounds that they are not comparable, being only notes made during official tours of inspection On similar grounds I would claim partial exemption for my own notes (Memoirs, Vol II, pt 2) published in 1864 I was then especially engaged with the Sub-Himalayan rocks, and my notes upon the older formations were taken on casual traverses of the ground, but I put them into the best form I could (unfortunately not a very lucid one) with a provisional scale of formations There would be no risk in so reasonable a proceeding, but for the delight some people take in figuring as correctors of what it gratifies them to call 'error,' and it is so easy in a reference to omit all notice of the saving clauses of the context, or to quote a passing opinion as if it had been a matured judgment It was my early connection with the college at Rurki that gave me the opportunity of Himalayan work, and since I left it (in 1862) no regular survey has been undertaken in this ground until now, though it is here, as I have often explained, that we must hope to find a clue to the whole Lower Himalayan region

After a preliminary view of the Simla section, Mr Oldham settled down upon Jaunsár, a British district between the Tons and the Jamna, because there he would have the advantage of a fairly good map on a sufficient scale, the Atlas maps of the general area being very defective The result has been no small surprise, which I will briefly explain The sequence of formations in the Simla section is apparently a simple one in itself, however complicated by disturbance There is at top a strong limestone, which takes its name from the Krol mountain, it is underlaid with apparent conformity by a great thickness of shales, slates, and flags, sub-divided by one small but very persistent band of limestone and conglomeratic quartzite known as the Blaini group It was thought that these rocks extended indefinitely eastwards, and Mr Oldham has himself recognised a known outcrop of the Blaini group far to the east of Jaunsár, beyond Mussooree, yet in the Jaunsár section, which takes in a full slice of the region from the tertiary zone to the gneiss, and is only 50 miles east of Simla, an almost completely new series of rocks is introduced, the limestone of Deoban mountain, north of Chakráta, being taken with some doubt to represent the Krol rock It rests unconformably upon a great series of slates and quartzites with subordinate limestone, but in this Chakráta series none of the infra-Krol sub-divisions have been recognised This discrepancy must, of course, stand, but it seems more likely to be explained as a variation of deposition than as an entire change of systems Unconformities, too, are of precarious certainty where disturbance has been so intense But the most interesting feature in the Jaunsár work is the introduction of two separate and entirely new groups It has always been known that a great gap existed between the tertiaries in the Simla section and the Krol group, for which no age later than the trias has been conjectured, but no

intermediate deposits had been detected In Jaunsár Mr Oldham introduces two unconformable and almost wholly detached groups above the Deoban limestone One, the Mandhális, may be of upper secondary age, but the other, the Báwar, is taken to be middle tertiary, as it exhibits little or no disturbance, although highly metamorphosed, it lies to the north, close under the main gneissic range All this may seem a little wild, but a perusal of Mr Oldham's paper will show that he thoroughly understands what he is about, and has completely protected his position, that if he scorns grooves and is somewhat reckless of antecedent probabilities, he has on the other hand a wholesome faith in close observation and sound reasoning

CHAMBA
Colonel McMahon

Colonel McMahon continues to favour us with his studies in the intervals of business His determination of the truly basaltic character of the bedded trappean and trappoid rocks associated with the slates of the Lower Himalaya removed an awkward uncertainty, but his later decision that much of the granitoid gneiss of the Himalaya must be regarded as a truly intrusive rock is a most valuable discovery, as giving a clue to structural features that were almost impossible of explanation on the supposition of the rock being stratified by original sedimentation When first describing this gneiss in the Simla region, Colonel McMahon remarked that "the internal structure of the rock is that which has usually been described as characteristic of an igneous rock" (Records, Vol X, p 222), and his later more leisurely study of the same rock with its attendant contact phenomena at Dalhousie has forced upon him the conviction that it is intrusive and must properly be called gneissose granite (Records, Vol XVI, p 129) His arguments are mainly drawn from the microscopical examination of petrological characters, and depend a good deal upon the more or less obscure conditions of the process of metamorphism and contact action, whereby very similar results may be accomplished in very different ways,[1] still the arguments are very forcible, and when backed by the more certain evidence of structural features, they seem to me conclusive Despite the wonders performed by flexure of strata in mountain regions, the structural features presented by this rock in certain cases were impossible of satisfactory explanation on the supposition of its being really stratified gneiss The Chor mountain in the Simla region and the end of the Dhuladhár ridge at Dalhousie are instances It is true that by Herbert originally, and by Strachey subsequently, the Chor was mapped as granite, by overlooking everything but the crystalline texture they hit upon the right name, but had they represented their conception of it in section, it would no doubt have assumed the conventional form of a vertically intrusive rock, whereas in reality the rock is not only foliated and roughly bedded, but it conforms in lie to that of the surrounding strata, presenting a steep south-westerly outcrop and a moderate dip conformable with that of the overlying schistose slates, the puzzle being that it has no continuity in strike, the outcrop being about as broad as it is long,

[1] I long ago brought to notice an instance of a perfect ternary granite where it can only have been formed by solution or hydrometamorphism, without intrusion or disturbance, or any conditions usually associated with the word 'plutonic' See Memoirs, Vol III, p. 17, and note by Professor Haughton, Journ Geol Soc, Dublin, I, p 87, 1864 65

nearly 7 miles The recent recognition of the fact that those characters of quasi-stratification are compatible with a truly granitic and intrusive origin, removes all these difficulties, and thus establishes a strong claim for acceptance

KASHMIR
Mr Lydekker

Although Mr Lydekker's work in the North-West Himalaya closed two years ago, and was duly noticed as it came out in his progress reports, the recent publication of it (Memoirs, Vol XXII) in a connected form and with a map of the whole area requires further remarks But for this compilation the work would be in a manner lost, and Mr Lydekker has performed his difficult task in some respects most creditably,[1] for it demands considerable art to put a mass of very crude material into presentable form, and this has been done, the volume now published gives an excellent general view of the distribution of the rocks over an immense area of very inaccessible ground In view of future operations it is however necessary to indicate explicitly how superficial this work has been Mr Lydekker remarks, and it is quite true, that anything like a study of the whole ground would demand a hundred-fold the time that has been given to it, we are told on almost every page that data are wanting to decide some point or other, showing a fair perception on his part of what was needed, but this only makes the almost total absence of critical landmarks the more disappointing

Although a considerable additional area of the sub-Himalayan region was mapped by Mr Lydekker, his attention was least directed to those rocks, and he has added nothing to the difficult question of their classification, indeed, the grouping he adopts (p 83) is neither congruous nor properly geological, the ruling question regarding them being whether the repetition of more or less similar deposits in successive zones up to the innermost boundary of the region are representative or distinct formations, and had he any real apprehension of the position, he would not have remarked (p 13) that the views regarding the upper tertiaries in our original work in this region (Memoirs, Vol III) had been modified It is true that a correction was published (Records, Vol XIV, p 169) of an erroneous observation of an important contact-section of the Nahan-Siwalik boundary, and that great stress had been laid upon that observation because it would have been an absolutely final settlement of an important dispute, but in publishing the correction it was expressly stated that all the other evidence remained in favour of the view originally taken of that boundary, that it was primarily an unconformable contact By far the most important and definite result of observation as bearing upon Himalayan history is that enunciated at page 121 of Mr Lydekker's memoir, but it would not be gathered from the context that this result had been very clearly concluded from our first study of those mountains, that although the Himalayan area had been elevated and defined, and the rocks deeply denuded before the eocene, little or no contortion of the rocks had attended that disturbance (see Memoirs, Vol III, p 174, 1864) Mr Lydekker has now extended this observation to the tertiary basin of the upper

[1] I must take exception to and apologize for the note on page 273 and the "(*sic*)" on page 274 of Mr Lydekker's memoir, which was printed in England I would be the last to check plain criticism of bad work, but to reproduce and point the finger at paltry errors of press reading in a quotation worthy of all respect, is a display of critical acumen that I trust may not again disfigure the pages of our Memoirs

Indus, but there is one important reservation that he has not noticed In his section on page 101, the tertiary strata lie at right angles to those of the gneiss, now the apparent conformity of the palæozoic rocks to the gneissic series is a constant subject of remark and puzzle with regard to the presumable existence of a prepalæozoic gneissic mass, if then the Indus tertiaries are in pseudo-conformable relation to the palæozoic strata there, the gneiss of the Skirbichan section would be a better identified example of that archæan gneiss than any of those suggested in Chapter IX

On page 127 Mr Lydekker makes some very judicious reflections upon the difficult question of the correlation of formations in Europe and in India, as introductory to the gigantic compromise he has to make in clubbing into one 'system,' 'the Zánskar system,' the eight formations, ranging from lower carboniferous to cretaceous, distinguished by Stoliczka at the east end of the Zánskar basin itself We must allow a good deal for the reputed extinction of fossils to the westward in these continuous deposits, nor should we complain of a temporary compromise had we found even a few critical landmarks for a classification which we must believe to be possible in that ground The map does attempt a three-fold division of the 'system' into carboniferous, jura-trias, and cretaceous, the three little patches of the latter being those marked by Stoliczka, but a map on so small a scale can only be an index to the text

The 'Zánskar system' is itself described as transitional with the underlying 'Panjal system' of lower palæozoic rocks, and these again are for the most part inseparable from the schistose metamorphic or gneissic rocks In the Manual (pp 626-7) the term 'central gneiss' was tolerated upon the intelligible grounds that we were then supposed to have in actual evidence two gneisses, one in the main Himalayan range, as testified by Strachey in Hundes and by Stoliczka in Bissáhir to be in abrupt original contact with the infra-silurian azoic slates, and another in Rupshu, as testified by Stoliczka to include all the lower palæozoic formations For the former the name 'central' was not inappropriate, in the sense of local fundamental or local archæan Later observation both in Hundes and Bissáhir asserts that on the north flank of the main range there is complete gradation of metamorphism from the gneiss to the slates, so it would for the moment appear as if we had only to deal with one period of metamorphosing action of variable range, or at least the original demarcation of two gneisses is not sustained Under these circumstances, as based upon an assumption, the use of so distinctive a term is scarcely for the present advisable It is true that Mr Lydekker insists upon the existence somewhere of a pre-silurian gneiss from which the blocks in the silurian slates must have been derived, but it is not certain, however probable, that that rock lay within the Himalayan region at all, and until found it would be better designated by some less specific name The reason given for preferring the name 'central' rather than archæan (p 269) is certainly not admissible, it is, that some of the so-called gneiss is now shown to be intrusive It would be rather subversive of geological principles to regulate the nomenclature of stratified systems according to the igneous rocks that may have invaded them, and it is clear that in this case the ambiguity is not in the words 'central' and 'archæan,'

but in the word 'gneiss,' if we choose to retain it for a rock that is proved to be a foliated granite, as which it should be coloured on the map whenever its origin can be established Or if the 'central gneiss,' as Mr Lydekker suggests (p 270), is only to indicate the lower limit of a general metamorphism as defined on the Bhabeh section, it would form an incongruous member in a scale of formations based upon wholly different conditions

Mr Lydekker continues the introduction to his description of the crystalline and metamorphic system with a discussion of Colonel McMahon's papers on the Dhuladhár, remarking that in the last of these "many of the rocks previously alluded to as granitoid gneiss are termed gneissose granite, and it will accordingly be understood that where these terms are employed they must be generally considered as equivalent" (p 271) It seems to me that this is precisely what we should avoid doing Compromise, or opportunism, may often be necessary, but in geology at least we can adopt it with our eyes open The familiar example of chalk and cheese would not adequately represent the confusion here recommended, it would be better illustrated as between blood and bone in biological research, a provisional equivalence which Mr Lydekker would hardly tolerate In the ascending scale of differentiation the possibility of mistake has there been removed, but intrinsically among rocks the functional distinction of gneiss and granite is just as radical Except by survivals of the Wernerian school gneiss is regarded as of sedimentary stratified origin, and even though locally derived by a new birth from the base of the earth's stratified shell, granite is essentially the very reverse of sedimentary I have no doubt Colonel McMahon would abstain from applying the term gneissose granite without sufficient reason, and meanwhile the term granitoid gneiss must carry its full signification, for it must be possible that a gneiss should reach the last verge of metamorphism without extinction of its original stratified relations, on the other hand, it would be difficult to place a limit on the pseudo-schistose texture an erupted mass may assume under certain conditions

In subsequent pages Mr Lydekker gives liberal extracts from Colonel McMahon's papers They will serve to give his non-professional readers an idea of what is understood by critical observation in geology, but they seem to be introduced as a basis for an imaginary contention (p 280) in which Colonel McMahon is supposed to deny the existence of the granitoid gneiss even in the Dhuladhár Seeing that the evidence quoted at top of the next page for the existence of an archæan series of metamorphic rocks in the Himalaya is from Colonel McMahon's observations (Records, Vol X, p 204) this is rather perplexing, the conclusion was not made from a thorough study of the ground, but it was formally sound, and it is almost the only positive evidence we have left on this important question, so I am anxious to see how it will stand the test of Mr Oldham's approaching investigation It is impossible to admit with Mr Lydekker (p 280) that the occurrence of boulders of granitoid rock in the slates of Pángi proves that such a rock was then exposed in Pángi, Chamba, and Kashmir, especially if those boulders were, as he conjectures, due to transport by ice, they may have come from much farther, possibly from the middle Himalayan region to the east.

With the fictitious contention over the archæan gneiss there is involved one on the intricate structural question of faulting *versus* flexure with inversion This too is peculiarly open to misunderstanding, for more or less of faulting would be inseparable from a folded flexure Colonel McMahon has not recognised any inverted strata in the Dalhousie section, and so does not yet see the need of the folded flexure Mr Lydekker has made out a good case for an inverted series on the outer flank of the Pir Panjál, and would extend it to the Dhuladhár, as these ranges are certainly homologous, and I think that in the main he is right, but here again it would not be supposed from his text that this was the view taken of the Dhuladhár in the first Himalayan work of the Survey (Memoirs, Vol III, 2, p 63, 1864)

NORTH WEST FRONTIER
Mr Blanford

The recent publication of Mr Blanford's memoir (Vol XX, part 2) on his examination of the hills in Northern Baluchistan and South-Eastern Afghanistan during the season 1881-82 brings forward some points that were not available for last year's report I need hardly say that the memoir is replete with sound observation and lucid exposition, or how much we have to regret that it is the last record of geological field-work in India that we can expect from Mr Blanford A slight alteration of the classification of formations adopted in his Sind Memoir is now indicated (p 46) according to the critical examination of the fossils by Dr Martin Duncan (Pal Ind Ser XIV) the *Cardita beaumonti* beds are now placed as lowest eocene instead of cretaceous, and the change is also rather in accordance with their petrological characters Their position below the trap had something to say to their being regarded as cretaceous, and now we have to give a corresponding lift to the trap itself which is presumed to belong to the period of the Deccan trap, this must have been one of great duration, and the eocene basalt of Ranikot would probably belong to its uppermost horizon The total disappearance of the Gáj and Nari marine beds of Sind in the western highlands as well as northwards is a very interesting observation The latter feature was a prominent object of Mr Blanford's investigation, with a view to the correlation of the sub Himalayan tertiaries, and although the examination was not carried so far northwards as was hoped for, the question is, I think, virtually settled as far as it is likely to be from this quarter, though perhaps not as Mr Blanford suggests The correspondence of the Manchhars of Sind with the Siwaliks has been fully recognised, and Mr Blanford has now traced them continuously along the Bugti and Suleiman hills, where for a considerable distance they overlap all the middle tertiary groups and rest upon the eocene The marine Gáj and lower Nari do not occur at all in this ground, but a sandstone which Mr Blanford takes to represent the Nari sandstone re-appears on the flanks of the Suleiman resting on the eocene shales, and he suggests (p 55) that it may represent the Murree beds of the sub-Himalaya I hardly think that this will prove correct The lithological resemblance is not so close as Mr Blanford supposes, "brown sandstone, rather harder and darker than the Siwalik sandstone," does not at all match the Murree or Dugshai rock, which has a prevailing purple colour and is densely hard There are rocks above the Murree horizon and below any recognised Siwaliks that would answer much better to the Nari sand-

stone of the Suleiman But this is the least consideration The intimate transition of the Murree beds and the eocene is not described as occurring at the base of the Nari in the Suleiman section, there is also a much greater thickness of deposits above the Murree zone in the sub-Himalayan region than above the Nari in the Suleiman These considerations coalesce with what must, I think, be taken as the probabilities of the case the exclusion of the sea from the northern ground was a most gradual change and no doubt took effect earliest in the north, where the highest marine and lowest fresh water deposits would thus presumably be older than at any point to the south It is not unlikely that the whole Sirmur series is eocene This sort of thing is no doubt awkward for the map maker, geologists must only learn to adapt their scales to the processes of nature

ASSAM
Mr LaTouche

At the other end of the Himalayan area, in Assam, Mr LaTouche was engaged, at the special request of the Public Works Department, in prospecting for coal and iron, where it was pretty certain none would be found, in the upper tertiary rocks forming the hills between Cachar and the Dimapur valley in Assam through which it is proposed to run a line of railway The result was as expected, but in proceeding to his work Mr LaTouche traversed some new ground, a note upon which is published in the Records for the year He was to have taken up during the current season the survey of the coal-field in the Gáro hills, his preliminary examination of which was made at the close of the last season (Records, Vol XVI, p 164), but with the permission of the Chief Commissioner he was deputed to accompany the survey party under Lieutenant-Colonel Woodthorpe, R E, proceeding to explore the Upper Dehing basin This would be very interesting ground, as it must reach beyond the zone of tertiary rocks fringing the Upper Assam Valley and probably beyond the range of the Arakan-Munipur axis Unfortunately this plan was interrupted by the Aka raid, the survey party being diverted into that territory, and Mr LaTouche with it This is Himalayan ground proper, not far to the west of the Daphla district visited by Colonel Godwin-Austen in 1865, and probably like it in structure

TINNEVELLY MADURA
Mr Foote

The Peninsula Area—Mr Foote completed his survey of the coastal region on both sides of Cape Comorin, and the result is now published (Memoirs, Vol XX, part 1) with a large map The region is not particularly attractive geologically One point of general interest has been provisionally suggested by Mr Foote The age of the Cuddalore sandstones has been unknown ever since the formation was first described by Mr H F Blanford under this name in 1863 (Memoirs, Vol IV, part 1), it occurs extensively in the Godavari district as the Rajamundri sandstone, and in Travancore as the Warkilli beds, and at many intermediate points It is totally severed from the cretaceous deposits of Trichinopoli, but as it had only yielded silicified wood and impure lignite, nothing could be fixed as to its age, and it has passed generally as tertiary Mr Foote has now (p 40) with some probability identified a fossiliferous marine sandstone as belonging to this group If this observation be upheld, or rather until it is contradicted, the Cuddalore sandstones must rank as post-tertiary or even sub-recent

In this connection I may mention the recent re-discovery of General Cullen's tertiary limestone near Quilon by Mr Logan, the Resident in Travancore In the annual report for 1881 (Records, Vol XV), I mentioned that Mr King had failed to find this interesting bed during his rapid survey of the Warkilli deposits (Records, Vol XV, p 94) It was certainly not to be found at the place assigned in the published account of General Cullen's observations, and no one at Quilon could put Mr King on the track of it Mr Logan has now sent specimens collected by himself at the spot, known as Purappakkara, about 7 miles north-east of Quilon, a much greater distance than that given in the notes published by Dr Carter General Cullen was presumably an Irishman

TERTIARY LIMESTONE AT QUILON

By desire of His Excellency the Governor of Madras Mr Foote at the beginning of the current field season took up the exploration of the ossiferous caves in the Karnul district, mention of which was made in last year's report Owing to the total want of local information regarding these caves there was much difficulty in finding them, and work was commenced in a cave said to be called Billa Surgam, but which turned out not to be the locality where Newbold had made excavations This cave was, however, found out in time, and the exploration has now made some progress with fair promise of success Unfortunately a diversion has arisen in an urgent demand for the examination of the country between Bezvada, Singareni, and Hyderabad, with a view to the possible occurrence of coal and iron deposits, in connection with a new line of railway No other officer being available it has been necessary to depute Mr Foote for this work, the cave exploration being for the time suspended

BILLA SURGAM CAVES

In March last regular mining exploration of the Umaria coal-field was commenced under Mr Hughes' direction by opening a shaft of 10 feet in diameter There being no suitable shelter on the ground the work had to be suspended during the monsoon, but an early start was made at the beginning of the current season, by the close of which it is fully expected a sufficient judgment can be formed of the value of the coal-seam It is also hoped that the survey of the much larger Sohagpur coal-field will be completed during this field season Mr Hughes continues to report favourably of the services rendered by Sub-Assistant Hira Lal

THE SOUTH REWAH COAL FIELDS
Mr Hughes

In connection with the coal-fields of South Rewah, the resources of iron for which the north of the Jubulpur district has long been noted assume much importance The information regarding the nature and extent of the ores not being as definite as was desirable, Mr Mallet was deputed to examine the question His report is published in the Records (Vol XVI, pt 2) It shows how exceptionally favourable all the other conditions are for extensive iron manufacture if the coal be found suitable

KATNI IRON ORES
Mr Mallet

Dr King returned from furlough on the 11th of May Before leaving Madras he was called upon to accompany His Excellency the Governor on his tour through the Cuddapah and Kurnool districts At the beginning of the current season Dr King took up work on the coal fields in eastern Chhattisgarh, commenced some years ago by Mr Ball He has been specially directed to select sites for trial

CHHATTISGARH COAL-FIELDS
Dr. King

borings in the Hengir Coal-field in connection with the projected line of railway

By prolonging the season's work well into the hot weather Mr Fedden was able to complete his survey of Kattywar The area is principally occupied by the Deccan trap, of which it was not desirable to attempt a detailed survey throughout, so the work lay principally in the tertiary and post-tertiary deposits of the coastal region, with some secondary rocks on the north-east margin To prepare his work for publication as well as to give assistance in the museum during Dr Feistmantel's absence and on account of the Exhibition it has been necessary to retain Mr Fedden at office during the current field season.

KATTYWAR
Mr Fedden.

After picking up some outliers of the marine cretaceous rocks in Khandesh and Nimar, Mr Bose extended his survey eastwards to Nimawar to take advantage of the new survey sheets of that ground The map required to illustrate Mr Bose's memoir of this large area is rather intricate, so there is some delay in publication For the current season Mr Bose has been transferred to the unexplored region of the upper Mahanadi basin, of which detailed maps are now available.

KHANDESH, NIMAR
Mr Bose

Sub-Assistant Kishen Singh extended his mapping of the Vindhyan lines, east of Bundi In the middle of the season he was recalled to Bengal, an urgent requisition having been made by the Public Works authorities for a search for limestone in connection with Barakar iron works and the new line of railway to the south-west Sub-Assistant Kishen Singh brought in numerous specimens of limestone from new localities in the gneissic rocks, but none of them were of better quality or more conveniently placed than that already in use I would here record the instructive fact that the native assistants are the first to complain of the heat and to propose a retreat from field work

Publications—Five parts of the Memoirs were published during the year, completing Volumes XIX, XX, and XXII The appearance of Volume XXII before Volume XXI has been unavoidable There were seven memoirs about ready to start and with nearly the same apparent prospects of a finish, and it was necessary to assign a place for each with a view to the lettering of maps and plates, once these were well in hand it was not possible to change Part 3 of Volume XIX is the catalogue of Indian earthquakes commenced long ago by Dr Oldham and now edited by Mr R D Oldham with a map of the principal seismic areas Part 4 is Mr Oldham's account of his observations in Manipur and the Naga Hills, the publication of which was delayed for the preparation of a map including the recent surveys Volumes XX and XXII contain the memoirs by Messrs Blanford, Foote, and Lydekker, of which notice has been given above

The Records for the year (Vol XVI) contain 24 articles of various interest with numerous maps and plates.

Of the Palæontologia Indica a full part containing a large section of the Brachiopoda of the Productus-limestone of the Salt-range by Dr Waagen was issued during the year, also a part on the tertiary Echinoidea of Kach and Kattywar, by Dr Duncan Two other parts are on the verge of publication, one by Dr Duncan on the Fossil Echinoidea of the Kirthar and Nari groups in Sind; and one by Mr Lydekker on the Siwalik Carnivora.

Museum.—The collections in the museum are in good preservation. Mr. Mallet's descriptive catalogue of the systematic series of minerals was issued in May, also, in December, his Guide to the Economic Mineral Products, giving a very instructive account of each class of substance, its use and distribution, with reference to the specimens in the cases. The foreign and Indian samples are placed separately in the several classes, as are also the samplos from the different provinces of India.

Library.—The additions to the library were 1,597 volumes or parts of volumes, 740 by purchase and 857 by donation or exchange. Numerous valuable offers of exchange for the publications of the Survey were received and accepted, with the sanction of Government. I am glad to be able to say that the promise made in last year's report has been fulfilled, the catalogue of the library is now at the press. But for the unflagging exertions of our librarian, Mr. W. R. Bion, this could not have been accomplished, in addition to his already sufficient duties as Registrar, he has devoted many spare hours of holiday time to preparing and arranging the slips for the library catalogue.

Seismometric observations.—With the co-operation of Mr. H. F. Blanford, Meteorological Reporter to Government, some simple seismometric instruments have now been set up at Silchar, Sibsagor, and Shillong, forming a minimum group for the determination of centres of disturbance in the Assam region.

Personnel.—Mr. Hacket was absent on furlough throughout the year, and Dr. Feistmantel went on furlough on the 28th March. Mr. Wynne left India on medical certificate on the 17th March 1880, and after repeated extensions of sick leave he had finally to be invalided, retiring from the service on 11th April 1883. When he joined in November 1862 he had had several years' experience on the geological survey in Ireland. In India some choice fields of work fell to him, such as Cutch (Kach) and the Salt-range, of which he has left well illustrated descriptions in our Memoirs. Mr. Lydekker too has not returned from the special leave taken in February 1882, having obtained extension of leave for 14 months without pay he resigned his appointment under an arrangement that permits of his completing the work he had in hand. He joined the Survey in November 1874, and his short career in India has been a very busy one. As soon as our collections were moved to the new museum and amalgamated with those of the Asiatic Society of Bengal, he undertook the arrangement and description of the extensive series of tertiary vertebrate fossils, large additions to which were made by Mr. Theobald in the Punjab. Mr. Lydekker's description of the Siwalik fauna in the Palæontologia Indica will form an enduring record of his zeal and ability. Two new assistants joined the Survey on the 28th December—Mr. Edward James Jones, A.S.R.M., and Mr. Charles Stewart Middlemiss, A.B. (Cantab). They have gone to be broken-in to camp life, Mr. Jones, with Mr. Hughes in south Rewah, and Mr. Middlemiss, with Mr. Oldham in the Himalaya.

H. B. MEDLICOTT,
Superintendent, Geological Survey of India.

CALCUTTA,
The 22nd January 1884.

List of Societies and other Institutions from which Publications have been received in donation or exchange, for the Library of the Geological Survey of India, during the year 1883

AMSTERDAM.—Netherlands Colonial Department.
BALLAARAT.—School of Mines.
BASEL.—Natural History Society.
BATAVIA.—Batavian Society of Arts and Sciences.
BELFAST.—Natural History Society.
BERLIN.—German Geological Society.
" Royal Prussian Academy of Science.
BOLOGNA.—Committee, International Geological Commission.
" Geological Institute.
" International Geological Congress.
BOMBAY.—Bombay Branch, Royal Asiatic Society.
BOSTON.—American Academy of Arts and Sciences.
" Society of Natural History.
BRESLAU.—Silesian Society of Natural History.
BRISTOL.—Bristol Naturalists' Society.
BRUSSELS.—Geological Society of Belgium.
" Royal Academy of Science, Belgium.
" Royal Geographical Society of Belgium.
" Royal Malacological Society.
" Royal Natural History Museum of Belgium.
BUDAPEST.—Geological Institute, Hungary.
BUFFALO.—Society of Natural Sciences.
CAEN.—Linnean Society of Normandy.
CALCUTTA.—Agricultural and Horticultural Society.
" Asiatic Society of Bengal.
" Calcutta Exhibition of Indian Arts and Manufactures.
" Economic Museum.
" Jeypore Exhibition for Indian Raw Produce, Arts and Manufactures.
" Meteorological Department, Government of India.
CAMBRIDGE.—Philosophical Society.
CAMBRIDGE, MASS.—Museum of Comparative Zoology.
CASSEL.—Society of Natural History.
CHRISTIANIA.—Editorial Committee, Norwegian North Atlantic Expedition.
COPENHAGEN.—Royal Danish Academy.
DEHRA DUN.—Great Trigonometrical Survey of India.
DIJON.—Academy of Sciences.
DRESDEN.—Isis Society.
DUBLIN.—Royal Geological Society of Ireland.
" Royal Irish Academy.

EDINBURGH —Royal Scottish Society of Arts
,, Royal Society of Edinburgh
GENEVA —Physical and Natural History Society
GLARUS —Swiss Society of Natural Science
GLASGOW —Glasgow University
,, Philosophical Society
GOTTINGEN—Royal Society
HALLE —Leopoldino Academy
,, Natural History Society
HARRISBURG —Geological Survey of Pennsylvania
HOBART TOWN —Royal Society of Tasmania
KONIGSBURG —Physikalisch-okonomischen Gesellschaft
LAUSANNE —Vaudois Society of Natural Science
LIVERPOOL —Geological Society
LONDON —Geological Society
,, Iron and Steel Institute
,, Journal of Science
,, Linnean Society
,, Royal Asiatic Society of Great Britain and Ireland
,, Royal Geographical Society
,, Royal Institute of Great Britain
,, Royal Society
,, Society of Arts
,, Zoological Society
LYONS —Association of Natural Sciences
,, Museum of Natural Science
MADRAS —Literary Society
MADRID —Geographical Society
MANCHESTER —Geological Society
MELBOURNE —Mining Department, Victoria
,, Royal Society of Victoria.
MILAN —Italian Society of Natural Science
MINNEAPOLIS —Minnesota Academy of Natural Sciences
MOSCOW —Imperial Society of Naturalists
MUNICH —Royal Bavarian Academy
NEUCHATEL —Society of Natural Sciences
NEWCASTLE-ON-TYNE —North of England Institute of Mining and Mechanical Engineers
NEW HAVEN —American Journal of Science
NEW ZEALAND —Museum of New Zealand
PARIS —Geological Society of France
,, Mining Department
PHILADELPHIA —Academy of Natural Sciences
,, American Philosophical Society
,, Franklin Institute
PISA —Society of Natural Sciences, Tuscany.

PLYMOUTH —Royal Geological Society of Cornwall
ROME —R Accademia dei Lincei
„ Royal Geological Commission of Italy
ROORKEE —Thomason College of Civil Engineering
ST PETERSBURG —Geological Commission of the Russian Empire
„ Imperial Academy of Sciences
SALEM, MASS —American Association for the Advancement of Science
„ Peabody Academy of Science
SIMLA —Quartermaster General's Department, India
SINGAPORE —Straits Branch, Royal Asiatic Society
STOCKHOLM —Geological Survey of Sweden
SYDNEY —Australian Museum
„ Royal Society of New South Wales
TORONTO —Canadian Institute
TURIN —Royal Academy of Sciences
VIENNA —Imperial Academy of Sciences
„ Imperial Geological Institute
WASHINGTON —Department of Agriculture
„ Smithsonian Institute
„ United States Geographical Survey west of the 100th Meridian
„ United States Geological Survey.
WELLINGTON —New Zealand Institute
YOKOHAMA —German Naturalists' Society
YORK —Yorkshire Philosophical Society

The Governments of Bombay, Madras, North-Western Provinces and Oudh, and the Punjab
Chief Commissioners of Assam, British Burma, and Central Provinces
The Commissioner of Northern India, Salt Revenue
The Resident at Hyderabad
The Comptroller General
The Surveyor General of India
The Superintendent of Government Farms, Madras
Departments of Revenue and Agriculture, Foreign, and Home

Considerations on the Smooth-water Anchorages, *or* Mud Banks *of* Narrakal *and* Alleppy *on the* Travancore Coast *By* W KING, B A, D Sc, *Deputy Superintendent, Geological Survey of India.* (*With a map*)

From time immemorial two anchorages on the west coast of Southern India have been known to mariners as presenting the marvellous feature of being perfectly quiet and smooth, while the sea outside may be tumbling in before the gales of the south-west monsoon The bottom, or ground, of these anchorages is also peculiar in being a very fine, soft, unctuous mud, which has over and over

again been supposed to act as a barrier against which the force of the waves was expended

In these quiet roads, ships are not only able to ride safely, but, so it is said, can sometimes take in water alongside, the sea beneath them being so diluted with fresh water from inland sources at this particular season Not only is there this wonderful quietness of the sea, but at times on one of the banks the smooth surface may be broken by burstings up, or huge bubbles—"cones" as they have been called—of water or mud from the sea bed, and even roots and trunks are reported to have floated up with these ebullitions Yet, again, the banks of mud are not fixed in position, but move along the coast within ranges of some miles in extent, or one of them may remain comparatively stationary, while the other may move, and these movements do not take place year by year as having a relation to the monsoon periods, but continue over many years

Unfortunately no continued series of systematic observations has ever been made with reference to these phenomena, so that no satisfactory conclusions could be formed as to their origin or causes From time to time, however, observations have been made, and suggestions offered, in explanation of them, some of which when looked into are very plausible, and may indeed be the right ones There is no doubt, however, that certain of these observations require corroboration, and with a view to this, the present paper—practically a compilation of previous knowledge—is now put forward

Within the last few years these banks have once more attracted attention first in a commission of enquiry into the harbours on the west coast in 1881, conducted by the then Superintending Engineer (Colonel R H Sankey, R E, C B) for Madras, and next by Mr Logan, the Acting Resident of Travancore, in his Administration Report for 1881-82 The Harbour Commission was carried on early in the year, when the conditions of the weather were altogether unfavourable to any exhibition of the features of these anchorages, the sea being generally quite calm, but I was enabled then to obtain some specimens of the mud An analysis of this showed its oily constitution, and thus some of the obscurity surrounding the action of the mud was cleared off Subsequently Mr Logan's evident great interest in the matter led to the writing of a paper by Mr Rohde, the Commercial Agent of Alleppy, which throws greater light on other features of the phenomena

By all accounts there are other but quite insignificant patches of smooth water and mud bank at various points along the Travancore and Malabar coasts, but those best marked and most generally known are near Cochin and Alleppy There is no well-defined situation for either of these banks on account of their movements to the North or South That near Cochin or the Narrakal bank may be said to lie between Cochin and the Cranganore river, 11¾ miles to the north, or the range over which it has been observed during the last 200 years is about 11¾ miles it does not appear to have ever passed south of the northern spit of the opening of the great backwater at Cochin, and for many years its position has been about the middle of the range, between the villages of Nairumbalum and Veearrakull (Narrakal) The other bank, 40 miles or so to the south of this, ranges from a mile or two north of Aulopolay (Alleppy) to Poracaud, a distance

of 12 or 15 miles it is now, and has been for several years, at the southern end of this range, and indeed goes often by the name of the Poracaud mud bank

The term 'Mud Bay' has been applied by writers and explorers to both anchorages, though there is no bay feature about either of them now An explanation of the use of the word 'bay' will be found in one of the extracts given further on

The mud banks are situated close along the beach, but extend out to seaward for some miles, presenting a more or less semi circular or flat crescentic convex edge to the long rollers and tumbling waves of monsoony weather Thus it is quite easy for boats or small canoes to put off from the shore

Ordinarily, during the non-prevalence of the monsoon, the sea is tolerably smooth, only rolling on the shore with more or less of a surf, and then these patches are only to be distinguished by the soundings of mud below them Even when the monsoon bursts, it is said that they are not always distinguishable at once, but generally only after a few days or so when the whole sea line has been affected and the mud at these particular places stirred up After this the muddy waters will calm down and so remain for the rest of the monsoon

The mud itself is essentially characteristic, and, as far as my limited experience goes of muds along this coast, unique It is, when brought up, of a decided dark-green colour, slightly tinged with brown, exceedingly fine in texture, only slightly gritty at times from fragments of comminuted shells, very soft and oily feeling, altogether just like a very fine soft ointment or pomatum After a time it dries and hardens, loses its oily feel, and becomes harsh like an ordinary mud It is easily stirred up on the bank, being in its upper part of great liquidity, the lead or the boat pole sinking into it from 3 to 6 feet below, it is more compact, and still deeper forms a good holding ground for anchors It has always been described as havgni a slimy or oily consistency, but that it actually contained oil has, I believe, only been surmised by a few observers, indeed, as will be seen further on, one scientific observer rather scouts the idea There is no doubt, however, that it does contain oil in appreciable quantity, as ascertained by analyses of the specimens obtained in January 1881, and sent up then to the Survey laboratory in Calcutta

The specimens sent up were as follows —

1017 Mud, off the Cochin river mouth, 4 fathoms
1018 Mud, from the Narrakal bank, 4 miles north, close in shore
1020 Mud, from Narrakal bank, off pier head, 2 fathoms
1019 Mud, from Poracaud bank, 7 miles south of Alleppy, 1 mile from shore, $2\frac{1}{2}$ fathoms
1021 Mud from Poracaud bank, 7 miles south of Alleppy, $2\frac{1}{2}$ miles from shore, 4 fathoms

My colleague, Mr F R Mallet, who made the assays, writes —

"All gave off, when subjected to distillation, some brownish yellow oily matter lighter than water, and looking not unlike petroleum No 1019 gave off the largest quantity, 1017 nearly as much, 1021 a smaller amount, 1020 very little, and 1018 almost none 1019 and 1021 were

digested with ether, which extracted a small quantity of brownish yellow greasy matter from them, the other samples were not tried in this way

"The quantities of mud sent were too small to allow of the oily matter (which in the case of 1019 only amounted to a drop or two) being subjected to examination"

A further point about the constitution of these muds is that they contain a considerable quantity of foraminiferal and infusorial remains, which were described by the late Captain Jesse Mitchell, Superintendent of the Government Central Museum, Madras[1] The foraminifera are referred to the genus Rotalina (D'Orbigny), and the Diatomaceæ are summarized as containing in all 62 species belonging to 30 genera He also says that the mud first received had a brown colour, but that a second supply, which was quite wet, had a somewhat greenish tinge, the colour depending on the quantity of water present Some, which had been exposed for several days to the sun, became almost white

I will now proceed to lay before the reader the further published information regarding these phenomena, and the theories as to their origin

Alleppy-Poracaud bank—The earliest account dates as far back as 1678 to 1723, in an extract from Hamilton's account of the East Indies in Pinkerton's Collection of Voyages and Travels,[2] which is given in the Administration Report for Travancore, 1860

"Mud Bay is a place that, I believe, few can parallel in the world it lies on the shore of St Andrea, about half a league out in the sea, and is open to the wide ocean, and has neither Island nor bank to break off the force of the billows which come rolling with great violence on all parts of the Coast in the South West monsoon, but on the bank of mud, lose themselves in a moment, and ships lie on it, as secure as in the best harbour without motion or disturbance It reaches about a mile long shore, and has shifted from the northward in 30 years about three miles

"A MS note has the following remark —This singular accumulation of mud still exists, and still affords the same convenience for anchorage in the worst weather The present account was published in 1723 and now in 1825 The mud bank has shifted from St Andrea in N Lat 90° 40′ to Poonaganot in N Lat 90° 25′, being 15 miles in 102 years"

Mr Maltby (then Resident) adds

The mud bank now (1860) is in latitude 90° 28 30″

The next account I can find is of much later date, in "Notes of an excursion along the Travancore Backwater," by Captain Heber Drury, 45th N I, dated 1858

"Alleppey,[3] Aulopolay, or Alapushe, as it has been variously named is the present commercial port of Travancore, and the principal depôt for Salt, Cardamoms, Pepper, Teak wood, and other products of the country It is reached by a canal leading from the backwater nearly due west, the length being about 3 miles" * * * * * * * * * * * * *

"Important as Alleppey is to the Travancore Government as a commercial depôt, from the facility of an inland water communication, which enables the forest products to be brought to the very doors of the godowns established for their reception, yet undoubtedly its greatest advantage as an emporium arises from the singular natural breakwater formed in the open roadstead, and which consists of a long and wide bank of mud, the effect of which is so completely to break the force of the houses (*sic*), that large vessels in the stormiest weather can securely anchor in the open roads,

[1] Jour, Madras, Lit and Sci, XXII, N S 6, p 264, *et seq*

[2] See, XIII, Public Works of Travancore Proceedings of the Madras Government, 1861 Published also in the Madras Jour Lit and Sci, XXII, N S 6, p 127, *et seq*

[3] Madras Jour, Lit and Sci, XIX, N S 3, p 217, *et seq*

where the water is as calm as a mill pond It is this extraordinary deposit which has earned for Alleppey the name of "mud bay" The origin of this deposition of so large a quantity of mud in the open sea about two or three miles from the shore, and so many miles from any bar or outlet from the backwater has never been satisfactorily accounted for From the circumstance of there being no natural outlet for the vast accumulation of waters which are poured down from the various mountain streams into the basin of the backwater nearer than thirty six miles on either side, it is not improbable that there exists a subterraneous channel communicating with the sea from the backwater through which the large quantity of mud is carried off and thrown up again by the sea in the form of a bank Being subject to tidal action the bank is more or less shifting at certain seasons, but not to a material extent It imparts a dirty-brown colour to the water for a considerable distance, and close to the shore the water is usually of a thickish consistency, being deeply impregnated with mud and slime"

Mr Crawford, the then Commercial Agent at Alleppy, thus reports to the Resident of Travancore—date, 20th June 1860[1] —

"Lieut Taylor attributes smoothness of the water to the soft mud at the bottom, which when 'stired up by a heavy swell from seaward the activity of the waves is so deadened as to render the shore line free from surf' I regret never having met Lieutenant Taylor

"A number of years ago, I brought to the notice of General Cullen, that the perfect smoothness of the water in the roads and at the beach at Alleppey was attributable, not to the softness of the mud at the bottom, so much as the fact of the existence of a subterranean passage or stream, or a succession of them, which communicating with some of the rivers inland and backwater become more active after heavy rains, particularly at the commencement of the monsoon, than in the dry season, in carrying off the accumulating water, and with it vast quantities of soft mud General Cullen, the Resident, sent a quantity of piping and boring apparatus in order to test the existence or otherwise of what I had urged Accordingly, I sunk pipes about 700 yards east from the beach and at between 50 and 60 feet depth and after going through a crust of chocolate colored sandstone, or a conglomerate mixture of that and lignite, the shafting ran suddenly down to 80 feet, fortunately it had been attached to a piece of chain, or it would have been lost altogether Several buckets from this depth were brought up, which corresponded in every respect with that thrown up by the bubbles as they burst at the beach, which I shall here try to describe as accurately as I can Due west of the Flagstaff and for several miles south, but not north of that, the beach will after or during these rains suddenly subside, leaving a long tract of fissure varying from 40 to 100 or 120 yards in length, the subsidence is not so quick at first, but when the cone of mud once gets above the water the fall is as much as 5 feet in some instances, when the cone bursts, throwing up immense quantities of soft soapy mud, and blue mud of considerable consistence in the form of boulders, with fresh water, debris of vegetable matter, decayed, and in some instances green and fresh These bubbles are not confined to the seaboard, but are, I am inclined to think both more active and numerous in the bed of the roads with the Flagstaff bearing from E N E to the South, until it bears N E by N, or even South of that About five years ago for about 4 miles down the coast and from the beach out to sea for a mile and a half, the sea was nothing but *liquid* mud, the fish died, and as these cones reared their heads above the surrounding mud, they would occasionally turn over a dead Porpoise[2] and numerous other fish the boatmen had considerable difficulty in urging their canoes through this to get outside of it, the beach and roads presented then a singular appearance —nothing to be seen but these miniature volcanoes, some silent, others active, perfect stillness of all around the ships in the roads as if in some dock, with a heavy sea breaking at 7 fathoms outside

"There are numerous deep holes, some of them I measured in 1852, one in particular just at

[1] Madras Jour Lit. and Sci, XXII, N S 6, pp 133-136

[2] A note is appended to this by Mr F N Maltby, the then Resident —"Porpoises are very numerous in the backwater."

the end of this canal [1] had as much as 60 feet in depth These holes may or may not communicate directly with the roads, but I think it will be found that the principal sources of active communication is more inland, and the backwater perhaps only as auxiliary About 3 miles above Chengannoor [16 miles east of Poracaud], in the river of that name, there is one or two deep "Linus," which I only had an opportunity of visiting twice, the first time, I had not the means of ascertaining the depth, the next, I lost both lead and line

"The depth of this passage [2] is not so great as you approach the beach as noticed above, for while extending the canal from the Timber Depot in March last, about 200 yards from the beach at 12 feet, we suddenly and unexpectedly broke through the substratum, when a column, fresh water, mud and vegetable debris, and about 9 inches in diameter, spouted up, which when left alone, gradually subsided as the upper stratum of sand filled in round the column of the spring

"I submit the above information as I feel it will be interesting, both to yourself and Government, to pursue the investigation of this subject more efficiently I have omitted to state one important particular,—that is, should *no* rain fall, as has been the case this year, the sea in the roads and at the beach is not *nearly* so smooth, up to this time we have had none of the mud cones bursting at the beach, neither in the roads, as the waves tumble in perfectly clear there was a heavy surf from the 26th ultimo to 9th instant, but never in any instance for those last 11 years has the rain held off so long as in this, and the roads and beach have always by the end of May been perfectly smooth To illustrate the perfect smoothness of the roads after the monsoon has fairly set in, a ludicrous event which occurred two years ago will suffice During a heavy westerly gale of wind in May 1858, a ship had to call at Alleppy for pepper bound to London The Captain, who had been frequently here before, sighted the light at midnight, and ran from the heavy sea into the smooth water of the road The small sail they had set was soon stowed and the anchor got ready, the leadsman being told to report when he got into 4½ fathoms Time elapsed, and considering the strong gale that was then blowing right on to the shore, the ship should have been in that water long before, but to every enquiry of the Captain '6 fathoms' was reported, until he took the lead line in his own hand, and discovered, for the first time, that the ship was aground! The anchor was let go, and notwithstanding the distance she had over run, she swang at once to the wind, and remained all night until the next afternoon, when the wind drawing more to the northward she made sail and stood out to the proper anchorage, remaining there, as she did when aground, still as in the London docks

"The fall of rain up to this time is only $7\frac{8}{10}$ inches since April, and from the 1st of January 13 inches only"

The latest notice [3] is that of Mr Rohde, the present Commercial Agent at Alleppy

"This anchorage known to the pioneers of commerce as Mud Bay is only apparent in the S W monsoon, and in 1849 its southern limit was ½ mile N of Alleppy, since which date it has steadily shifted to the South, and for the last 3 years has decreased in area each monsoon The original theory seems to have been that the bank travelled year by year southwards and then suddenly resumed its original place, but from the various observations taken, this seems to be an error, and from the notes I have made during my 13 years residence on the Malabar Coast, I believe that Mr Crawford, the former Commercial Agent and Master Attendant of Alleppy, and who, in addition to 30 years' residence in Alleppy, had previous nautical experience of the coast, was correct in his conclusion that the bank of mud is created by the hydraulic pressure caused by the level of the vast backwater being, in the S W monsoon, some 4 feet higher than the sea It has been proved by boring that although Alleppy appears to be one vast sand tract it has at a depth of 60 feet * a *soft mud foundation,* and both Mr Crawford and I have seen mud volcanoes bursting up in the sea during the rainy season Those that I have witnessed only appeared as if

* Borings taken near the flagstaff 20 feet *thick*, no less

[1] A short canal connects the backwater with the beach

[2] The supposed underground passage —*W K*

[3] Para 231 of Report on the Administration of Travancore for the year 1881 82 (W Logan)

a barrel of oil had suddenly been started below the surface, but Mr Crawford has seen some burst and throw up roots and trunks of trees, and it would appear that the mud bank thus formed is gradually carried down the coast by the littoral currents, and after a certain distance has been travelled, gradually wastes away, and that in place of this bank returning to its original position it is a fresh mud bank that is thrown up at certain periods in the vicinity of Alleppy, which, it should be noted, has the narrowest strip of land between the backwater and the sea The theory that the mud bank is immediately connected with and due to the height of the backwater being above the sea was, I think, conclusively proved this monsoon, as at the height of the floods, when the canals were 6 feet above ordinary level, the area of the smooth water off Alleppy was so great that it was only by means of a good telescope and standing 20 feet above sea level that I could see the breakers and heavy rollers beyond the half circle of smooth water This flood was on the 13th June and was followed by a rapid fall, and the half circle of smooth water of the sea beach contracted as the waters fell The floods again rose inland, and the smooth water circle expanded in proportion

This may explain the Alloppy bank but Narrakal is fixed I think, however, he is right

This is very good evidence

"The mud itself is of a peculiar character and so soft that a light lead (4 lbs) put over the end of a pier apparently shows 2 fathoms of water, but on drawing up the line, 6 feet is found to be water and 6 feet soft oily mud

"There are other points which, although I do not profess to sufficient scientific knowledge to show the connection between, with the mud bank, I think should be noted, as this natural smooth water anchorage has been a source of much discussion in scientific circles, and I believe that any notes given of the formation of the land must be of interest

"I cannot give dates as I have no records, but it is certain that the coast from about north of Calicut to south of Quilon was once well above the level of the sea, and was after a long period totally submerged and then again was thrown up by volcanic action and has again been partially covered by sea I state this because in cutting the Warkilli tunnel, trees were found, and also shells have been found on the coast which are known to belong to a class of shell fish that only live in very deep water Remnants of a fort at Poracaud were visible 30 years ago, and at Calicut and Vypeen massive buildings are now in the sea

"Secondly, I should note that deep pot holes exist in the big lake East of Alleppy of from 20 to 70 feet in depth, which, seeing that lake is for the most part only a few feet deep, is a curious circumstance and would tend to strengthen the belief that I have heard expressed, that subterranean rivers connect the backwater with the sea

"The area of the lake to which I refer is nearly 100 square miles, and its nearest point to the sea, 3 miles With a rise of 4 feet, or as occurred in the floods of 1882, of 6 feet, it can be easily believed that the enormous pressure thus caused would force relief ways for itself below the coast line through soft mud easier than through ground which is densely covered with cocoanut trees, the fibrous roots of which bind the ground into a solid mass

"A similar mud bank exists off Narrakal, and I have often heard it put forward as an argument that mud banks on this coast do not shift, but I think the steadiness of the bank off Narrakal is due to the enormous body of water which pours out 6 miles south from the Cochin harbour and which scouri throws up sand banks which probably tend to prevent the shifting that would otherwise take place

I would rather say the sand banks at mouth of Cranganore river prevent the littoral current—N to S—from carrying it away
W L.

"Other smaller mud banks occur at different places, but are of too small an area to be available for any shipping business, but they all show a progressive tendency southwards"

Narrakal, or Cochin, Bank—The only information I can find concerning this bank is from two papers in the Madras Journal of Literature and Science,[1] by Dr. Day and Captain Mitchell.

[1] Vol XXII, N S 6, pp 260 and 264,—1861, "Narrikal or Cochin Mud Bank." By Francis Day, Civil Surgeon, Cochin, and "The Mud Bank at Narrikal, near Cochin, its composition, as exhibited by the microscope." By Lieutenant J Mitchell

In the first, the following extract is given from Stavorinus, the Dutch Navigator, who so far back as 1777 wrote —

"Coast is safe and clear everywhere along the Company's establishment, except at the mouth of the river of Cranganoor, where there is a reef at the north side which stretches out to the sea, about three quarters of a league, it is called the reef of Aycotia by our Navigators, before Coylang (Quilon) there is a similar one but which does not extend half so far out South of the above mentioned mouth of the river of Cranganoor, there is a bay, formed by mud banks likewise one not far from Porca, and another south of Cochin the banks forming which extend full a league out to sea, and into which vessels may run with safety during the bad monsoon, and may lie in twenty and less feet of water, almost without anchors or cables, in perfect security against the heavy seas, which then roll in upon this lee shore, as they break their force upon the soft mud banks, and within them nothing but a slight motion is perceived"

Dr Day continues —

"In Horsburgh's East Indian Directory, fifth edition 1841, page 512, it is stated under the head of Cranganoor Fort—'From the south point (of Aycotia or Cranganoor river) a mud bank with 3 fathoms on it, projects out near two miles to seaward'

"From the foregoing it appears that a bay protected by mud banks existed between the mouth of the Cranganoor river towards Cochin in 1777 and then appears to have been well known At present, the same protected spot exists, but it is no longer a bay, and for the following reason Though the northern projection of the coast at the mouth of the Cranganoor river, forming the northern extremity of the 'mud bay,' is still present, the southern projection, or that between Narrikal and the mouth of the Cochin river, is gone, having in fact been covered by the sea (at this place a church stood, which is now submerged) had it not been so, a 'mud bay' would still be present. It is curious that this law of encroachments of the sea is now the rule on the Western Coast, because tradition[1] and an examination of the geology of the country both lead to the conclusion that the sea formerly washed up to the Western Ghâuts, thus Malabar has been literally raised from the sea

"During the south west monsoon, the rivers on the Western Coast swell to a great extent, and become loaded with alluvial deposits Should any obstruction occur at their outlets, deposits sometimes take place, as at the Cranganoor and Quilon rivers, where mud banks have been so formed Whether the impediment to the alluvial deposit being carried out to sea is merely owing to the action of the S W monsoon causing a great impetus to the waves as they meet the river at its exit, or whether other causes also obtain, must be questioned In forming the Narrikal mud bank, a reef of rocks, the Aycotia reef, at the mouth of the Cranganoor river, appears to have prevented the S W monsoon from causing a divergence of the river's mouth to the northward (as invariably takes place on the western coast unless that bank is protected), this reef (Aycotia) has probably assisted in the formation of the Narrikal, or, more properly speaking, the Cranganoor mud banks

"The whole of the long islands, between the backwater and the sea, are evidently merely alluvial deposits, brought down by the various rivers in their course from the Western Ghâuts The direction of these mud banks being the same as the long islands and the character of the soil being similar, demonstrates the causes of their origin to be probably identical In short, the mud banks are alluvial matter, brought down by the rivers and deposited in the sea where it meets the force of the S W monsoon[2]

"Though *Narrikal* owing to its being the nearest place to Cochin is mentioned, the density of the water is greater proceeding towards the Cranganoor river It becomes very thick and black, and large pieces of flat hard mud begin to be perceived lying on the shore, about one mile

[1] "In a MSS account of Malabar, by Hernan Lopez de Castaneda, in 1525, it is said that little more than 2,300 years ago the sea came up to the Western Ghâuts"—(Note by Dr Day)

[2] "During the S W monsoon, the sea for several miles beyond the entrance of the larger rivers is no longer salt"—(Note by Dr Day)

north of Narrikal, having been thrown up by the sea Passing on towards Cranganoor, a large bank of the same substance exists, evidently brought down by the river, and this is one source from which the mud bay receives a fresh supply"

* * * * * * * * * * "No gases arise from the water, nor oily substance (as has been suggested) floats upon it It is simply the action of the sea which prevents the subsidence of the mud, for as soon as placed in a still vessel it sinks The shore is sandy, but amongst the sand alluvial deposit exists The smoothness of the sea is well described by Stavorinus"

* * * * * "The mud has an unctuous sticky feeling, and is not gritty unless mixed with sand It is of a very dark greenish colour, has but a slight odour and subsides in water —Cochin, 5th September 1861"

I have already referred to the organisms described in Captain Mitchell's paper, but he thus writes of the banks and the mud —

"Captain Castor reports the existence of an extensive mud flat, which, commencing about half a mile south of the village of Narrikal, extends to the north for about four miles Within this space, in the height of the S W Monsoon, he found the sea without a ripple! But the greatest stillness of the sea and the total absence of surf from the beach prevailed between a village named Narambolum and Narrikal a distance of about one and a half miles,—at this point Captain Castor was always able to embark from the beach in a small canoe

"The mud appeared to be exceedingly soft and permitted a 7 lb lead to penetrate it to the depth of three feet in some parts where there was a superstratum of from six to ten feet of water Beyond the depth of sixteen feet the bottom attains greater consistence and appears good holding ground Three miles and a half from the shore the depth was five and a half fathoms and gradually shoaled towards the shore We are left to conclude that the bank extends to that distance from the shore, but this is not distinctly stated in the published account

"The small quantity sent to me was damp, and appeared very firm and tenacious, it had, however, been somewhat compressed by the waterproof wrapper in which it was packed To ascertain if it contained any minute shells a portion was placed in water, but it did not break up readily, and as I wished to avoid any violence that would destroy such delicate structures, I allowed it to soak for twenty four hours On shaking it up at the expiration of that time I found that at least half of it could not be separated in that way I therefore pressed it gently with a glass rod, it resisted the pressure, much in the way that a stiff piece of jelly would do, exhibiting considerable elasticity, as well as tenacity, and it is doubtless these properties that enable it to break the force of the waves —acting like an immense spring, it yields to their pressure, but in the encounter the water loses its force and becomes quiescent, while the mud gently expanding again is ready for a fresh encounter"

I will now conclude this descriptive portion of my paper with a short geographical sketch of the country exhibiting these phenomena,—that is, from the Cranganore river southwards to Quilon This range of coast is about 92 miles long it is tolerably straight—without an indentation giving at all the form of a bay—except at the extreme ends, where, at Cranganore, there is the long southerly trending spit of the northern side of the river's mouth, by all accounts, for I have not visited it, a reef perhaps of laterite or lateritoid rock, and again at Quilon, where a sort of bay is formed by another great reef of laterite or lateritoid rock belonging to the Cuddalore Sandstones of the Survey classification, or the Warkilli beds of local geology Much less is there any indication of a bay near Alleppy The fact is, notwithstanding the argument of Dr Day in the extracts given above, the term "Mud Bay," which has been applied to both places, may perhaps have been adopted for an imaginary bay of smooth water enclosed within the semi-circle of breakers outside There is no doubt that a portion of the

land near the Cochin end of the Narrakal bank was submerged, the church which stood on it having been known to men now living, but there is, I believe, no knowledge of this land having had the form of a projection like the southern arm of a bay Be this as it may, the present shore line is a straight one from the Cranganore spit to the Quilon or Tungumshery reefs, and it is low-lying or only a few feet above the level of the sea, and made up of alluvial deposits and sand Inland from it, the same low lying deposits, broken by backwaters, extend eastwards for several miles forming the lowest portion of the low country proper of Travancore and Cochin Then the ground rises, sometimes suddenly, to a low terrace, now much cut up and broken by denudation, which forms the rest of the low country below the elevated mountain land or backbone of this part of Southern India The low country—that is, alluvial flats and inner low terrace —seldom attains a greater width than 30 miles

The long stretch of alluvial deposits bordering the sea is broken by several backwaters or lagoons, the largest of which is that extending northwards from the parallel of Alleppy to, and communicating with, the backwater of Cochin The Alleppy backwater is very wide at its southern end, 8 or 9 miles, but it is not directly behind Alleppy, much less behind the Alleppy-Poracaud mud bank, though the principal rivers entering it flow northwards behind the range of this mud bank There is no visible communication between the Alleppy backwater and the sea, there being no river mouth of the least importance all along this coast, except at the Cochin backwater, and at Cranganore The rivers of the country behind Alleppy merely flow into the Alleppy backwater, and, for all that can be seen to the contrary, its waters flow out at the Cochin mouth.

To all appearance, the flat lands of the coast are entirely recent alluvial deposits, consisting of layers of sand and mud overgrown with vegetation, and no doubt held together by the roots of this vegetation The water of the lagoons is more or less brackish and unfit for drinking, but shallow wells sunk in the narrow coast tracts between lagoon and sea give fresh water It is not, however, certain—although it is most probable—that other deposits, besides the merely recent alluvial ones, exist along this coast, for at the Quilon end there is every reason to expect that the Cuddalore sandstones (laterite) are underlaid by a peculiar set of clays and muds with seams of lignite and other vegetable matter, like those exhibited further down the coast at the base of the Warkilli cliffs [1] It is true that the dip of the Warkilli clays and lignite is to the northward, and that they must, or ought—provided no disturbance has taken place—to lie deep under the Tungumshery laterite, but this dip is very low, and a rise of these strata again further to the north would not be unusual Certainly the lumps of blue clay, described by Mr Crawford as being turned up in the "cones" of mud or water off Alleppy, answer to the lumps of clay which have fallen down from the lower part of the Warkilli cliffs and the lumps of hard mud mentioned by Dr Day as occurring at Narrakal, which I have also seen myself, have a similar constitution and looked to me as though they had been broken off from outcrops in the Narrakal sea bed Mr Crawford also mentions his having passed through a "crust of

[1] See Rec G S I, Vol XV, pt 2, p 93

chocolate-colored sandstone, or a conglomerate mixture of that and lignite," which strata answer very well to certain rocks at Warkilli

The proper alluvial flats do not extend further east from the shore line than 14 or 15 miles, and the further inland alluvial flats of the rivers, which are very distinct and wide, do not extend further east than 20 or 22 miles thus the absolute head of water which could be obtained in subterranean water-bearing strata would never be very high Indeed, for all practical purposes, in this connection, the head of water looked for in the surmises of previous observers, can only be that attained by the flooding of the backwaters

The term "volcanic" has been used occasionally by previous observers, perhaps rather as a descriptive term than as referring to any volcanic action, but the elevation or depression of the land is fully recognized as having taken place within comparatively recent periods It is, however, a question whether there may not be an intimate connection between some of these earth movements and a line of volcanic action which, though now latent, is apparently indicated by the lie of the Maldive and Laccadive groups of coral islands, and yet further north, the "Angrias" and "Direction" banks At the same time, I do not wish to press this, possibly to some readers far-fetched, volcanic element into the discussion, except in so far as that it may not be lost sight of in future observations Besides, as will be seen, I do not think the observations made up to this time, or the theories offered in explanation of them meet all the features exhibited by these Travancore mud banks

On a close review of the information given in the various papers above quoted, it is clear that both banks have practically the same constitution, behave similarly, and have the same accompaniments, with the exception of the violent discharges of mud or oil, which, so far as our knowledge goes, are confined to the Alleppy-Poracaud bank

In considering first the mud itself of these banks, it is to be remarked that it is full of organic matter, and that it contains a sensible amount of oil, some of which may have been derived from the decomposition of organisms In all seasons it is easily stirred up, and it never settles down into a uniformly compact deposit, but has an upper stratum in a greater state of liquidity than its lower depths It occupies particular areas within well-defined ranges of movement, it certainly moves from north to south within these ranges, but there is no surety that it moves back again This movement continues over periods of years

Now with regard to the progress southwards ceasing at certain points, as at the northern edge of the Cochin river mouth and at Poracaud A satisfactory explanation can, I think, be given for Narrakal, in the Cochin river, which always flows out at a great rate, carrying the mud out to sea We have no such mode of transport evident at Poracaud The southerly movement must be attributed to littoral currents acting over long periods on tenacious muds, which may really only be evolved in large quantities at intermittent periods Mr Rohdé's suggestion that the mud bank of Alleppy does not travel northwards again, but becomes dissipated at the southern extremity of its range, is very plausible

Regarding the water over the mud it is only known to calm down during the south-west monsoon There is no observation showing how it may be affected

in stormy weather at other seasons. Still, I was led to understand, when in personal communication with Mr. Crawford[1] in 1881, that the calming of the anchorages does not take place until after the monsoon has commenced, and there has been a stirring up of the sea and mud. The quieting of the waters is intensified according to the amount of rainfall during the monsoon; but even if no rain fall, there is a certain amount of quiescence. The calmness continues throughout the monsoon, apparently without any fresh stirring up of the mud. In one locality at least, the water is subject at times to violent agitation through the bursting up of gigantic bubbles of water, mud, or gas,—it is not quite clear which; and these features also appear to be intensified during heavy rainy weather in the monsoon periods. The water over the banks becomes considerably freshened, even to the extent—as I was told by Mr. Crawford—of being drinkable; also according as the monsoon rains are light or heavy. At such times, also, the water gives off fetid odours, and the fish inhabiting it are killed off in large numbers; but whether owing to the freshening of the sea-water, or the exhibition of poisonous matter and vapour in the water, is not clear: perhaps this destruction of life may be due to both causes.

The old idea of the mud bank acting as an elastic barrier against which the wild seas sank into such marvellous quietude must be given up in part at least, now that we have got the more reasonable soother of troubled waters in the oily constitution of the mud. There is, of course, the difficulty of citing, or indeed the absolute want of, authoritative observation of the action of oil on troubled waters; but tradition and anecdote are undoubtedly in favour of it, while there are the newspaper accounts of the experiment which was tried a year or so ago in the harbour of Peterhead, when a stream of oil was cast upon the heavy seas at the harbour's mouth with such success, that vessels were enabled to run in with comparative ease. Even, while writing the present paper, I have had an opportunity of trying a very simple experiment on one of the Calcutta tanks, while a slight breeze rippled its surface. On throwing in about a wine-glassful of petroleum or earth-oil on the lee side of the tank, the oil spread out rapidly over the water against the breeze; the effect was instantaneous and decided, the sharp ripples being quieted down to longer smooth undulations, while there was a distinct semi-circular edge of the oiled water beyond which the ripples kept up their sharper action. In another place, on the side of the tank past which the breeze was blowing, a handful of the oil was thrown out on the waters. The oil immediately spread itself over the water in a thin film, along the outer edge of which the freshening breeze occasionally combed the wavelets, and within the area of the film the ripples were smoothed down to quiet and long undulations. The effect soon passed off, however, while the film of oil soon lost its sharpness of outline; so that it is evident if any continued quietness is to be kept up in water with oil, the supply of it must be continuous.

In the case of the mud banks, it can easily be conceived how the stirring up of the mud in the beginning of the monsoon should produce temporary calmness;

[1] Mr. Crawford is now living in retirement on the Purmerd hills of Travancore, and it was here I had the pleasure of talking with him about the Alleppy coast, which he knows so intimately for more than thirty years.

but there is considerable difficulty in accounting for the long continuance of quiescence without any fresh stirring up There is certainly the fact that the upper stratum of mud continues in an extreme state of liquidity or attenuation in the water, and that thus a sort of restlessness and freeing of oil particles may be going on for a long period, but I think we must look to a further supply from hidden sources, which are indicated by the more violent burstings forth of water, or mud, or oil, in the form of "cones"

An observation which would have been of the greatest use in this enquiry is wanting, however, and that is as to the condition of the surface of the water at such times, or, in other words, whether a film of oil exists on it

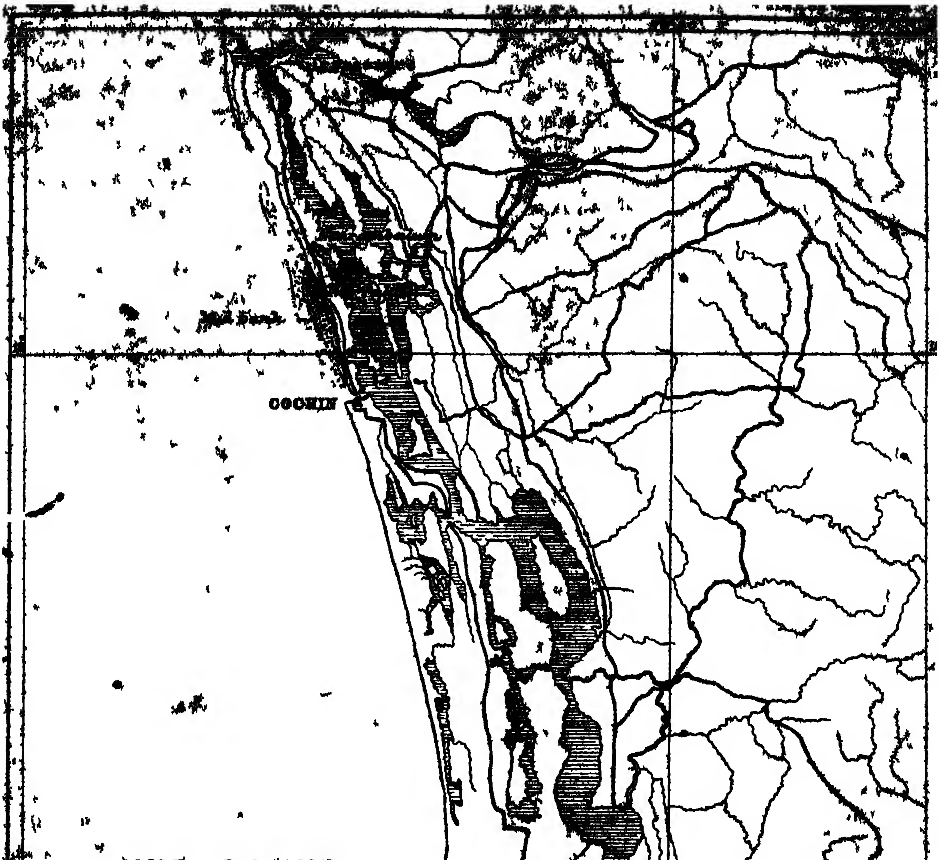
The amount of oil derivable from the decomposition of the animal and vegetable matter of the organisms in the mud would be, I am inclined to think, hardly sufficient to account for the features exhibited, hence it is necessary to look to other sources for the oil, and even to a source for the continued supply of the mud itself, which is evidently carried away and distributed by littoral currents

The consensus of observation and opinion certainly leads to the conclusion that there is an underground discharge of water at any rate into the sea from the lagoon and river system behind the Alleppy-Poracaud coast during flood time, the inland waters being at a higher level than the sea The accounts of such a condition of affairs at the Narrakal bank are, however, not so clear, besides there is the free opening at the Cochin river mouth Still, underground discharges of lesser intensity may take place, while the lesser pressure likely to be brought to bear on this part of the seaboard may also account for the absence of violent exhibitions like those off Alleppy This passage of underground waters, as suggested by Mr Crawford, must then, more particularly during heavy rains, force out large quantities of the mud on which the Alleppy Poracaud land rests,—as it were like a floating bog, elastic and capable of yielding to pressure, or exerting pressure by its own weight, while a continuous stream, even though very small, of the same oil and mud, may be kept up under the lower pressure of ordinary backwater level Not only would the underlying sludge and its products be forced out, but it is conceivable that the mud from the backwater should find its way into the same vents, and for a time replace that carried off in the first instance, oil and gases being absorbed in it during that time of replacement

Excessive floods in the monsoon time only occur at long intervals, and the greater discharges of mud, oil, and gases would then take place, in fact just as they really do at irregular intervals At such times new banks might be formed, for, during the quieter intermediate season the old ones might be distributed down the coast by littoral currents, and become finally dissipated into the open sea

Be this as it may, if Mr Crawford is right, then the source of the mud is evident, and its expulsion from beneath the Alleppy land is explained at once by the hydraulic pressure inland, if it even be only through a head of 6 feet at abnormal periods of flood time

Speculation of this kind must, however, be kept in abeyance, until further evidence is obtainable as to the character of the sludgy stuff under Alleppy, and of the muds in the backwater, particularly over the deep holes referred to by Mr Crawford, as also of the mud in the sea outside the banks themselves A deep


MUD BANKS.
of
NARRAKAL and ALLEPPY
on the
TRAVANCORE COAST
COCHIN
Mud bank

boring at Alleppy itself would clear up much obscurity, and it might tell more of the supposed Warkilli beds

The presence of petroleum has in any case to be accounted for, and, up to this time, there is no observation showing that it occurs in any of the lagoon deposits *per se* There is at the same time an indication of the possibility of other deposits besides the alluvial ones, in the fact that large lumps of clay or compacter mud, and vegetable remains in a more or less decayed form, are brought to the surface during the prevalence of the violent ebullitions Mr Crawford, it must not be forgotten, also mentions his having met with a chocolate-colored sandstone or a conglomerate mixture of that and lignite Such clays do occur in the Warkilli deposits, and they are associated with lignite beds, in which occur trunks and roots of trees in every stage of decay, some completely carbonized, and others so fresh that they can be cut up and used for making furniture It may then be that these Warkilli deposits extend northwards under the Alleppy-Poracaud alluvium, and even again at Narrakal, where also fragments of similar clays are thrown up by the sea, and that it is from those deposits as being deeper-seated, older, and lignitiferous that the earth-oil is generated I am even inclined to look further for an agent in the generation of this oil, like that adduced by Mr Mallet in his paper on "The mud volcanoes of Ramri and Cheduba,[1]" where he suggests the possibility of oil and gas being generated in lignitiferous strata under the influence of moderate heat arising from a line of volcanic energy, such a line, as I have suggested, possibly lying parallel to the west coast of India

However, for the present it is best to keep within the sphere of more evident causes shown by the observations which have been made Thus, the conclusion seems inevitable, that the banks, their smoothening influence, and their position within certain ranges of the coast, may be entirely due to the following causes First, the discharge of mud from under the lands of Alleppy-Poracaud and Narrakal, this being effected by the percolation or underground passage of lagoon water into the sea Second, the presence in this mud of oily matter, derived perhaps in part from the decomposition of organisms, but principally from the distillation of oil in subjacent lignitiferous deposits belonging presumably to Warkilli strata Third, the action of littoral currents which, slowly and through long periods of years, carry the mud down the coast to certain points whence it is dissipated seawards,—by the Quilon river at Narrakal, and at Poracaud because it is there beyond the range of replacement

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Rough notes on Billa Surgam *and other* caves *in the* Kurnool District, *by* R BRUCE FOOTE, F G S, *Deputy Superintendent, Geological Survey of India*

The following notes embody the results attained up to the present by the examination and partial exploration of Billa Surgam and several other caves in Kurnool district This work was undertaken at the instance of His Excellency the Right Honourable M E Grant Duff, Governor of Madras, who had been

[1] Records, G S I, XI, pt 2, p 100

requested by Professor Huxley to procure the further exploration of "Billa Surgam," a place where the late Captain Newbold, F R S, had discovered some ossiferous caves The caves had been practically lost sight of for many years, and their locality was quite unknown to the district officials, both European and native, and to many of the natives even in the near neighbourhood Captain Newbold's very brief paper on these caves, published in the Journal of the Asiatic Society of Bengal in 1844,[1] was unknown to my colleague, Mr King, when he surveyed that region, and remained unknown to him (and myself) till after the completion of the work in Kurnool district

My visit to the neighbourhood of Banaganpalli, which is the nearest place of any importance to the caves, resulted in the re-discovery of Billa Surgam and the fresh discovery of several other caves, one of which is of large size and of great interest geologically, as being a very typical example of the solvent and eroding action of water in limestone on a large scale

Billa Surgam

Billa Surgam lies on the south side of a narrow valley opening on the east side of the Yerra Konda or Red Hills, the range of low hills and plateaus forming the western side of the Kurnool basin Its position is a mile north-north-east of that assigned to it by Newbold, and it lies 3 miles east-south-east of Betumcherru (Baitumcherloo) in the south-eastern corner of Nandyal taluq It may be described as consisting of three deep but very short "cañons" joined by natural arches The various caves open into the cañons at different levels The cañons themselves were once caves of large size, the roofs of which have fallen in, in great part The ground plan of the place may, for sake of illustration, be compared to a rather distorted figure of 3, the two principal caves being situate on the right side of the upper and lower parts of the figure The floor of these two caves is considerably above the level of the bed of the stream, which in wet weather flows through the cañons These two caves are the only ones answering to Newbold's description, both, and especially the larger one, are well furnished with stalactites, and in the latter it is probable that a large quantity of stalagmite will be found under the present floor In both cases this is formed of a loose blackish-grey soil, largely made up of the dropping of birds, bats, and other animals The walls of the larger (southern) caves were unfortunately in the occupation of a large colony of wild cliff bees, no fewer than 18 nests, several of immense size, hung within the cave and immediately above the place where excavation should have commenced The presence of such an element of danger[2] prevented

The two Bone Caves

[1] Note on the Osseous Breccia and Deposit in the caves of Billa Surgam, lat 15° 25', long 78° 15', Southern India By Captain Newbold

[2] These cliff bees (*Apis dorsala ?*) are of very unreliable temper, and the natives are much afraid of them Though often inoffensive, they are sometimes roused and sally forth and attack with great fury any human being or animal they may come across When working at the Yerra Zari Gabbi (cave), where there was a very large colony of bees, they got excited several times and swarmed down furiously into the mouth of the cave, luckily their great noise gave us warning and we could escape into the dark passages, whither they would not follow At

me from commencing there at once, and I began with the smaller northern cave inside which there were no bees' nests

This northern cave is 70 to 80 feet high and 32 feet wide at its mouth, and decreases in height to 4 feet,[1] 86 feet from the mouth Its extreme end is formed by a small passage, too narrow and too low to be followed up by an adult Through this passage and a number of small clefts in the sides the mass of red cave earth filling the bottom of the cave was doubtless washed in The cave earth as far as excavated showed few pebbles washed in from above, but masses of limestone, often of large size, have fallen from the roof in such numbers as to add very greatly to the labour of excavation in some parts

The northern cave.

The floor of the cave when I first entered it consisted of a loose blackish-grey soil, largely composed of the droppings of blue pigeons and small animals living in the cave This layer was thickest at the upper or east end of the cave, and thinned out with the slope of the ground westward Its greatest thickness was about 4 feet, and it contained a few traces of human beings having inhabited the cave, among them were two small chank shells (*Turbinella* or *Mazza*) with the apices of their whorls broken off These had doubtless been the property of a Gossain or some other religious mendicant A few bits of broken pottery and one or two bits of charred wood were also found in this surface layer In several parts of the cave the black soil was found to be full of bones of small animals, birds, lizards, frogs, and of exuviæ of insects and myriapoda which appeared to be derived from the castings of predacious birds I made a full collection of these for purposes of comparison with the numerous bones of small animals, which, according to Newbold's account, abounded in the red cave earth below[2] These bones from the upper layer were in no way fossilized,—indeed many of them were quite fresh

On removing the surface layer a bed of loose loamy red soil was exposed, which had at many points been manifestly disturbed, but to no great depth Resting on this disturbed surface close to the north wall of the cave at a spot 21 feet westward from the mouth of the small passage which forms the east end of the cave, was a small number of human bones not mineralized but deprived of their animal matter Among the bones, which were all much broken, are fragments of a skull, teeth, ribs, &c

Billa Surgam, however, there were no dark passages into which to retreat After some time I succeeded in getting the nests removed by honey gatherers, but, despite that, many of the swarms showed no inclination to migrate elsewhere, and remained when I left, fully ten days after the destruction of their combs Those that left seem to have joined the Yerra Zari Gabbi colony I had had 26 large nests destroyed there in hope of getting rid of the inhabitants Many left but returned again, and about a month later I found the colony had increased to 40 nests It is impossible to smoke them out on such high cliffs, and the only way to get rid of them will be to blow them up with powder

[1] The heights given above were those taken before the removal of the cave earth was commenced

[2] The day after I commenced excavating at Billa Surgam, a number of people from the adjacent hamlet of Kotal came over to look at my proceedings, and one of them, a very old man, volunteered the information that he remembered Newbold's visit, and that his excavation was made just a little to the west of mine He added that Newbold remained about three weeks at Billa Surgam

From the very small number of bones found here, it is more probable that they were introduced to the cave by some beast of prey than that they were relics of a burial That these caves afford occasional shelter to wild animals at the present day, is shown by the fact that most of the narrow passages have been built up by the villagers to prevent the beasts from remaining permanently I found no traces at Billa Surgam of the continued residence of either leopards or hyenas, the most common of the larger carnivora in these parts, though there was no reason, judging from the quiet mode in which the cave earth had been accumulated, why the Album Græcum formed by those animals should not have been preserved, as well as the many minute bones which occur scattered through the cave earth

Character of the cave earth

A little below the surface the cave earth was found to become generally clayey, and in parts a very stiff clay Red is the prevailing colour, and the fallen masses of limestone of all sizes, adverted to above, are found distributed throughout and give the whole a distinctly bedded appearance No stalagmitic flooring was met with as far as my excavation extended, which was to a depth of 15 feet, but several bones were found in the disturbed upper part of the cave which appear to have been derived from a stalagmitic breccia I thought at the time these might possibly have been specimens lost accidentally during the progress of Newbold's excavation, but I did not meet with any other indications of exploration It is, however, quite possible that his excavation was made on the north side of the cave and will be found when further exploration extends thither My excavation was directed towards taking out systematically the whole mass of cave earth of the southern half down to the rocky floor, and it was carried out down to a depth of 14 feet I began with the south side as getting the most day-light and being therefore the most advantageous for observing the section

I am puzzled to know what Newbold meant by a "gypseous rock," unless he referred to some kind not met with in the northern cave

All the bones that were disinterred during my excavations belong, so far as it was possible to judge from cursory inspection, to living species, but seeing of what great antiquity the caves must be if estimated by the vast amount of denudation the country generally has undergone since their formation, there is no *primâ facie* reason for doubting the existence of remains of greater geological antiquity in the lower parts of the cave deposit

Prospects of further results

From the situation of the Billa Surgam caves with regard to the hills adjoining and to the stream flowing through the series of cañons, I consider the prospect of really valuable finds very good, and would strongly urge a continuation of the exploration in an exhaustive manner The brightness and comparative dryness of the caves must have made them very suitable retreats for savage men as well as for cave-loving animals, while the peculiar character of the material washed in has clearly been very favourable to the preservation of bones The smaller caves are equally promising with large ones, and there are several rock shelters in other limestone scarps, and especially in one north of the hamlet of Kotal, which should be

explored It is by no means unreasonable to hope that remains of palæolithic man might occur in them, for I picked up an oval quartzite implement on the talus on the north side of the valley lying between the Billa Surgam ridge and that north of Gorlagootta

The Yerra Zari Gabbi

This large and important cave which I had the good fortune to discover opens at foot of a great limestone cliff on the eastern slope of the Yegunta Konda, a small plateau 6 miles north-north-west of Banaganpalli It takes its name from the great red cliff the "Yerra Zari" in which it is situated and which forms a conspicuous feature on the flank of the plateau, but the mouth of the cave which opens into a very wild and rugged ravine is so hidden by trees that it cannot be seen till one approaches within a few dozen feet It is quite invisible from the open country below This cave also was unknown to the people at Banaganpalli, though it lies within the Banaganpalli territory The cave was formed by the action of a stream rising on the plateau of Paneum quartzite which caps the limestone The stream was formerly of considerably greater length and volume than at present, and formed a complicated series of chambers and passages which I propose to describe fully with plans and sections in another paper The floor of the cave is level for a distance of 160 feet, when it divides into two, and the main one begins to rise for a distance of 130 feet till it reaches a kind of platform under a lofty roof which opens into a vertical pot hole 162 feet in height Under the pot-hole the main passage bends nearly at a right angle to the west and continues rising greatly for more than 130 feet in distance, when it is blocked by debris A great talus of angular limestone masses fills this passage and much of the slope below the platform About the middle of the lower slope the water falling down the pot-hole has formed a considerable mass of stalagmitic breccia The great side chamber has had its upper end breached and huge rolled masses of quartzite have fallen into it from above The main stream seems to have flowed through this passage for a considerable period, judging by the rounding and polishing which the great quartzite blocks have undergone Water still flows through in considerable quantity after heavy rain, but the main stream from the plateau now avoids the cave and flows through the wild ravine to the eastward An immense amount of debris has been brought into the cave by the streams that have flowed through it I made three deep sinkings in different parts, one (No 4)[1] a little distance within the mouth of the cave which reached the rocky bottom at a depth of 27 feet, another (No 1) in a large side gallery westward of the mouth which failed to reach the bottom at 33 feet, and a third (No 3) in a higher-lying side gallery which reached the bottom at 26 feet In the side galleries the surface layer is rather loose black soil with much organic matter, chiefly bat droppings, in it This showed traces of human tenancy of the cave at several levels At No 3 sinking a quantity of antique pottery was unearthed, some of it of excellent quality, but with the exception of one little drinking cup of glazed black ware[2] all was broken It attracted a good deal of

[1] The numbers in brackets refer to the order in which the sinkings were made

[2] Of one large chatty I succeeded in finding nearly every piece, so that it can be built up by careful cementing It shows a very striking style of ornamentation, very different to anything modern

attention from the natives, who were much struck by its great difference from the pottery now made in that quarter This pottery was found at a depth of 2½ feet At a depth of 11 to 12 feet in the same place were traces of a fireplace, and close by lay the drumstick of a common fowl

At sinking No 1, broken pottery occurred at a similar depth The pottery was of the same character as that obtained at No 3 At the depth of 11 to 12 feet was an old fireplace with many small fragments of charcoal Some cowdung ash-balls such as used in *āgdans* and several lumps of rather decomposed shale showing strong traces of fire With the above were various fragments of very coarse pottery

The loose black surface layer was not found in the main cave at No 4. There the surface layer consisted of 2½ feet of limestone rubble, under which came the cave earth, which was a brown muddy loam passing into stiff clay of brown or reddish-brown colour, generally full of fragments of decomposing calcareous shale, angular or water-worn fragments of limestone, some washed in, others fallen from the roof, occur at intervals near the surface, but were often numerous at greater depths At a depth of 3½ feet in the cave earth was a fragment of some marrow bone (apparently ruminant) which showed marks of teeth Small splinters of bones of good size were not uncommon in the upper part of the cave earth, but all were undeterminable At a depth of between 12 and 13 feet was a minute but perfectly unmistakable piece of antique bright red pottery, probably the oldest trace of man met with in the cave

Of three other excavations made in this cave only one was of real importance, of the other two, one was stopped by meeting the bottom of the gallery at a depth of little more than 3 feet, and the other was not brought to a final conclusion In sinking No 5, a little below the middle of the high incline leading from the main body of the cave up to the pot-hole, about 12 feet of hard brown or drab stalagmitic breccia were quarried through in a good-sized pit, and a soft bed of drab-coloured breccia reached, but in neither was even the minutest fragment of bone discovered It should not be concluded that these sinkings are a sufficient test of the contents of this great cave, for though from its darkness and dampness in wet weather it would not be fitted for a dwelling place, it would from its out-of-the-way position form an excellent hiding place It is more than probable that the pottery found in the different passages had been left there by refugees who had occupied the cave temporarily The only approximation to a legend in connection with the cave that I succeeded in extracting from the people was a story that it had once served as a place of refuge to the inhabitants of a fort that formerly stood on the edge of the plateau above Yegunta temple, after the fort had been captured during a war

Both at the Yerra Zari Gabbi and Billa Surgam the walls of the passages are delicately fretted by the action of water trickling down their surface, and the beautiful sections of the limestone thus prepared afford a very strong proof of its unfossiliferous character If organisms even of very delicate nature existed in it, some few would most assuredly have been worked out by the action of the flowing water which has that effect in so many other places I examined the cave walls, as far as they were within reach, very carefully, and saw not the faintest indication of any fossil

Yegunta and other Caves

A considerable number of other caves of smaller size exist in this limestone district, several of which are unquestionably worth further exploration There are three caves at the Yegunta pagoda in the ravine immediately north of the Yerra Zari Gabbi Two of these are enlarged rifts along lines of jointing in the limestone, their walls show bunches and fringes of stalactites here and there, but their floors are concealed by flagging and steps built by devotees who have erected shrines there Exploration of these caves is of course out of the question at present The third cave is a shallow one which is choked at its back with a considerable mass of reddish stalagmite-breccia The very clear and well-displayed face of this mass of breccia shows thousands of included fragments of shaly limestone, but after careful examination I could not detect a single trace of bone

In the group of limestone cliffs south of the Yerra Zari Gabbi are several rifts with stalactites, but too small even if they are ossiferous to contain any large quantity of fossil remains under the piles of angular debris now forming the visible floor

At the south end of the cliffs what seems to be the top of the arched mouth of a considerable cave shows just above a great talus of limestone blocks, the result of a fall from the cliff The presence of a permanent flowing spring emerging from the talus a little distance renders the existence of a cave in the hill above it very probable

In the group of high limestone cliffs on the south side of the second ravine north of the south-east corner of the Yegunta plateau is a large and deep recess with one or more small caves opening near the top of the cliff These I was unable to reach for want of a long ladder and because of a large colony of bees that would not be dislodged. From the promising look of the place I think it deserves a very careful examination

Billam Cave

Fifteen miles to the south-west-by-south of Banaganpalli there is a cave which was described to me by an intelligent native as of some size and interesting as forming the source of a fair-sized perennial stream This cave is near the village of Billam (Bollum of sheet 76)

Caves near Gorlagootla

To return to the neighbourhood of Billa Surgam On the south side of the great cave ridge and about half a mile due south of it is a small one exposed by a slip of the hill side The cave is entered by a very steep climb down a rift to a depth of about 30 feet At the bottom the true floor is hidden by debris which also fills up a passage running westward so much that it cannot be followed even by crawling on all-fours for more than three or four yards, but the Gorlagootla people say it joins the Billa Surgam caves The place had been recently inhabited by a leopard Very little stalactitic matter was seen encrusting the walls This cave is not easy to find, as its mouth does not show till one is within three or four yards of it It opens on to a small terrace 20 to 30 feet long, and occupied by two small but thick trees. The terrace lies about half way up the grassy slope of the ridge and faces eastward

I was told of two other caves of moderate size to the westward of Gorlagootla, but was unable to visit either from pressure of work at Billa Surgam One of them was said to occur in the valley of Gorlagootla stream, and will probably be found in connection with a very fine group of limestone cliffs stand-

ing on the north side of the stream The other, of which the locality was pointed out to me, is situate in a picturesque ravine which one passes on the left-hand side when crossing the small ghat which leads from Gorlagootla to Betumcherru

Lastly, I heard of a cave near Buganpilly, 3 miles north-east of Betumcherru, but could gather no reliable information about it

From the rather barren character of the soil formed by decomposition of the quartzites and limestones of this region, it is pretty certain that even the virgin forest which once covered the Yerra Konda was by no means impenetrable, and this renders it the more probable that its glades and recesses were familiar to the Palæolithic stone folk, very numerous traces of whom in the shape of quartzite implements were found by Mr King and myself in 1865 near Roodrar only 30 miles to the east-south-east

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Notes on the Geology of the Chuári *and* Sihunta *parganahs of* Chamba, *by* COLONEL C A MCMAHON, F G S

Official duties having required me to visit Chuari and Sihunta, the opportunity presented itself of gaining some information regarding the geology of that part of Chamba, though, my leisure being necessarily limited, I was not able to devote as much time as I could have wished to a detailed examination of the rocks

As Chuári itself has been described in my paper on "The Geology of Dalhousie,"[1] the following pages will deal with the section between Chuári and Sihunta and the neighbourhood of the latter village

The first fact to be noted is the disappearance of the outer band of gneissose granite,[2] which is typically developed about a mile south of Chuári I saw no trace of it on the road to Sihunta, though the road crosses all the rock series from the silurians to the siwaliks, nor in the course of the numerous traverses I made to the north and north-east of Sihunta The mica schists which, in the Dalhousie area, occur next the gneissose granite at the base, or somewhere towards the bottom of the silurian series, are typically developed in this section, but the gneissose granite is absent The dip of the slates on the Sihunta road is N.-E 11° N

The carbo-triassic series continues to crop out east of Chuári, but it becomes greatly attenuated in this section The bridge over the Chaki (Chuckee) below Raipur (Rapir) is on the limestones of this series, but the band is apparently a thin one, whilst in the bed of the Chanál, under Sraog, the whole outcrop of this series does not attain a thickness of much more than 50 or 60 yards

The Dalhousie altered basalts crop out next the limestones at the bridge under Raipur, and thereafter the road runs with these rocks to the vicinity of Samót (Samoat), where they, in their turn, disappear I failed to obtain any trace of them east of this point Samót, and the land between it and Sihunta, is, for the most part, well covered with post-tertiary alluvial deposits, but I searched carefully along the beds of streams and I am satisfied that the trap dies out

[1] Records XV, 34

[2] My reasons for calling the outer band gneissose granite are given in a paper to appear in the next number of the Records.

between Samót and Sihunta. A good section is obtained in the bed of the Chanál under Sraog, and only about 50 or 60 yards of the carbo-triassic series interposes there between the siwalik sandstones and the mica schists of the lower silurians.

In my paper on the Dalhousie area, I noted that the sirmur series had been cut out by a fault south of Chuári, and the conglomerates of the siwalik series brought into contact with the trap. This feature appears to persist in the Chuári and Sihunta section. At Kanora (apparently Samoat of the map)[1] a coarse breccia resting on red clay, dipping N.-N.-E. at a low angle, is in contact with the trap. These rocks, and those which occur further east, are of siwalik aspect; and I did not, in this region, see any rock along the inner horizon of the tertiaries that I could identify as a member of the sirmur series.

I made an excursion up the Diarh *nadi* one day and found that the gneissose granite appeared exactly where I expected to find it north-east of Tikri (Tikiria). At Tikri, the rocks on both sides of the stream are silurian slates, and they continue up to the gneissose granite with a dip to E. 11° N.

In the hills north-east of Sihunta a surprise awaited me. About three quarters of a mile, as the crow flies, from the horizon of the carbo-triassic series, a fine-grained gneiss, or gneissose granite, crops out to the north of Sraog at an elevation of 4,100 feet, and 1,000 feet above Sihunta. The rock is a perfectly crystalline combination of quartz, felspar, muscovite and dark mica, but exhibiting a well-marked foliation or parallelism of structure. In weathered boulders it is not possible to distinguish between it and the fine-grained, non-porphyritic variety of the Dhúlar Dhár gneissose granite. Higher up the ridge, the Sraog rock becomes more schistose in aspect, and finally becomes superficially very rotten from weathering. The transition from this fine-grained rock to the larger-grained highly porphyritic gneissose granite of the Dhular Dhár is a sudden one. The fine-grained rock appears to be older than the porphyritic gneissose granite, for I observed a large boulder of the former in an affluent of the Chanál close to and east of Sihunta, which contained large intrusive veins of the coarser-grained porphyritic rock. An examination of these veins left no doubt in my mind of their intrusive character.

There seems no ground for supposing that this fine-grained foliated Sraog rock is an extension of the Dalhousie "outer band." The latter occurs below the mica schists and a great thickness of the silurian slaty series interposes between it and the porphyritic gneissose granite. The Sraog rock, on the contrary, occurs above the mica schists and slates, and appears to be in contact with the porphyritic gneissose granite.[2] Moreover, though they are composed of the same minerals, there is no resemblance in their macroscopic aspect between hand specimens of the "outer band" and the Sraog gneiss.

[1] The real position of Samót is apparently where Kania is marked on the map. Tundi bears N.-W. from Samót, not S. W. as shown on the map. I tried every conceivable mode of pronouncing Kania, but no name at all like it was known in Samót.

[2] I climbed the ridge to an elevation of 6,200 feet, and reached a point abreast of Tikri. I had no time to go higher, moreover it was blowing half a gale, a snow storm was coming on, and the natives with me were suffering acutely from the cold.

On my ascent, my way lay for some distance up a stream between Sraog and Pukuru. The actual contact of the gneiss and the slates was not visible there, but on my descent along a spur of the mountain by another route, the passage from gneiss, or gneissose granite, to indurated slates was sudden. These slates are highly altered, and indeed assume quite a foliated aspect when in contact with the gneiss. A little further on, the gneiss re-appeared again for some yards, and then slates similar in character to the first.

The dip of the mica schists and slates between Sraog and the gneiss varied from N.-E. to N., and, taken in connection with the E. 11° N. dip of the slates at Tikri, they would thus appear to dip into the gneiss all round. The mica schists and slates appeared to me to be lower and middle silurians.

Whether the Sraog rock is another case of the intrusion of gneissose granite or whether it is of pre-silurian age—the remains of ancient land on which the silurians were deposited—is a question regarding which I think it would be premature to offer an opinion in the present paper. Careful field work, and microscopic investigation in the laboratory,[1] will need to go hand in hand for a long course of years before all the details of Himalayan geology can be successfully worked out.

The spurs south-west of Tikri and north-west of Samót are so thickly covered with boulders that I could only get a glimpse in one place of the slates on which they apparently rest, though I traversed these spurs for some miles. Indeed, so thickly are these boulders scattered over the hill sides, that the suspicion crossed my mind that a local eruption of granite had taken place at this spot and that the boulders had weathered out *in situ*. I could find no evidence, however, to support this idea, for even when small landslips had removed the superficial vegetable deposits nothing was revealed but broken boulders beneath.

The next idea that naturally occurred to the mind to account for these accumulations of boulders was glacial action; indeed not only here, but all round Sihunta and on the road between that place and Chuári, huge blocks of granite are scattered about over the hill sides in a way to suggest the former existence of such action very strongly. Blocks are found perched on the undulating edges of spurs and dotted over the sloping sides of the mountains. The alluvium of the valley is studded with them; accumulations of boulders here and there assume a very moraine-like appearance; whilst the heads of little upland valleys, formed by the bifurcation of spurs, where evidently no stream of any consequence has ever flowed, are thickly strewn with them.

One block, measuring 26 × 19 × 7, I found perched on the crest of a ridge west of the Dairh river, on the Chuári road, at an elevation of 4,000 feet and 1,200 feet above the present bed of the Dairh. Another block, measuring 29 × 25 × 18—and there are numbers of others of about the same size—I found at an elevation of 3,000 feet above the sea, resting on the surface of a rice-field on the south side of the valley at Sihunta.

The antecedent improbability of a glacier at the latitude of 32° 18' extending

[1] As I have only just returned from this trip, I have not had time to examine thin slices of the Sraog rock under the microscope.

down as low as 2,000 feet above the sea—for the blocks go down at least as low as that—is very great, but it might be argued that water power could not be called in to explain the transport of a block containing 13,050 cubic feet of granite, for a rush of water of sufficient volume and velocity to carry 13,050 cubic feet of granite in a single block down a slope of about 1 in 20 would have scoured out the whole valley and carried away every particle of the soft alluvium with it, whereas these blocks are not found buried in a boulder bed surrounded with shingle, but resting on the surface of a thick deposit of soft mud These and other arguments that could be advanced to prove the former presence of local glaciers, seemed to me unanswerable, until I found that a gneiss, or gneissose granite, large weathered blocks of which are undistinguishable from similar blocks of the fine-grained variety of the Dhúlar Dhar granite, occurs as low down as 4,100 feet above the sea Now that we know that this massive rock crops out within three quarters of a mile of the siwalik horizon, and less than 2 miles from Sihunta, the difficulty is in a great measure removed, and it does not seem necessary to resort to a glacial theory to explain the presence of blocks so near their place of origin

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Note on the occurrence of the genus LYTTONIA, *Waag*, *in the* Kuling Series *of* Kashmir, *by* R LYDEKKER, B A, F G S, F Z S

Since the publication of my memoir on the Geology of Kashmir[1] a new genus of brachiopods, from the "Productus-limestone"[2] of the Salt-range and adjacent districts, has been described by Dr Waagen under the name of *Lyttonia* The genus has also been obtained in the carboniferous of China

On seeing the figures of the Salt-range specimens, I at once recognised fossils not unfrequently occurring in the Kuling series of the neighbourhood of the Kashmir valley, whose affinities I had long been at a loss to determine They are found on weathered surfaces of the limestone rocks in several parts of the northern side of the valley, but more especially on the high ridges to the north-east of Srinagar The rock in which they occur is so hard that I was unable to chisel out specimens sufficiently perfect to carry away

Judging from memory, I think that the common Kashmir form is *L nobilis* It is a fact of much interest to find this remarkable genus adding another to the long list of forms common to the "Productus-limestone" and the Kuling series of Kashmir

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A pair of quernstones made of arkose, from near Dhararah, Monghyr District

PRESENTED BY MR R S BION

Four specimens of marble, from Jaipur and Ajmere

PURCHASED

6 specimens of Bhanrer (Vindhyan) sandstone from Rupas quarries, Bhartpur

PURCHASED

[1] "Memoirs," Vol XXII

[2] "Pal Ind," Ser XII, Vol II, pp 396 403; plts. XXIX—XXX

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January 14th, 1884

Government of India Central Printing Office.—No. 26 S G S —16-2 84 —720

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1884 [May

Note on the Earthquake *of 31st December 1881, by* R D Oldham, A R S M, *Geological Survey of India.* (With a map)

On the morning of the 31st December 1881 a severe earthquake was felt over a large portion of the Indian peninsula and Bengal, affecting also the Burmese coast and causing much damage in the Andaman and Nicobar islands A considerable amount of material, comprising newspaper extracts, official reports and private letters, having been placed at my disposal, I propose giving a brief notice of the more important features of the shock

In Bengal it was felt as far as Chunar (?), Gaya, and Hazaribagh, Akra, in the 24-Parganas, was shaken, and at Akyab it was followed by the eruption of a mud volcano in Ramri [1] There is no record of its having been felt at Rangoon or Moulmein, at Tenasserim it is doubtful, though it was felt in the Mergui archipelago, to the south it is reported as having been 'severe' at Acheen in Sumatra, and in N Lat $3^\circ 54'$, E Long $91^\circ 21'$ it was felt by the ship *Mount Stuart*, at Ootacamund it is recorded, as also at Calicut thus the area over which it was felt measures about 1,600 miles from north to south and 1,500 miles from east to west, or 2,000,000 square miles in all

Such briefly is the summary of the information contained in the daily papers, and as no observation of scientific value is recorded in them which has not been placed at my disposal in another form, I shall refrain from repeating the vague, when not misleading, statements of the time and nature of the shock which were so given to the world [2]

There is, however, one published notice which contains much valuable information I refer to the note by General Walker, and Major M W Rogers, R E (originally published in the Annual Report of the Trigonometrical Survey, and

[1] Records, G S I, Vol XV, p 141

[2] I may, however, mention one letter by Mr W G Simmons of Calcutta published in the *Indian Daily News* He seems to have been at some trouble to collect information, and I have to thank him for liberally placing it at my disposal

reprinted in the Proceedings of the Asiatic Society of Bengal, March 1883, page 60) on the records left by the earthquake, and its consequent sea-wave on the tidal gauges fixed along the shores of the Bay of Bengal, illustrated by reductions from the original records and a chart of the Bay of Bengal, on which Major Rogers has marked what he considered to be the focus of the disturbance For the benefit of those who may not have access to the original, I subjoin a short abstract of the information contained

At Port Blair, the forced sea-wave, indicating the arrival of the earth-wave, is indicated at $7h$ $44'$,[1] the first sea-wave arrived at $8h$ $3'$, followed by others at 15 minutes interval, with a height of 3 feet from crest to hollow, the disturbance not subsiding entirely till $21h$

Diamond Harbour --Sea-wave hardly perceptible, arrived at $15h$ $10'$

Dablat —First sea wave at $13h$, disturbance continued till $21h$

False Point —Forced sea wave at $7h$ $54'$ Sea-waves small, the first arrived at $11h$ $15'$

Vizagapatam —The sea wave arrived at $10h$ $43'$, followed by others until midnight

Madras —Sea-wave arrived at $10h$ $18'$

Negapatam —The first wave, which arrived at $10h$ $15'$, measured 4 feet from crest to hollow, and was followed by others until midnight

Paumben —First wave at $11h$ $32'$, disturbance lasted till midnight

At Calcutta the time of arrival of the earthquake was noted by Mr James Murray, who writes, in reply to my enquiries, that he was reading in an upstairs room when feeling the shock he immediately ran downstairs and marked on the glass of his standard regulating clock the exact position of the second's hand and then waited to note the time of cessation of the motion, afterwards he carefully took with a second's watch the time that it occupied to do all he had done between the moment when he first felt the shock and when he made the mark on the glass of his clock, adding this and the error of the clock on that morning, he obtained the times of commencement and cessation as $7h$ $37'$ $45''$ and $7h$ $42'$ $0''$, Calcutta mean time, or $7h$ $55'$ $2''$ and $7h$ $59'$ $17''$ Port Blair mean time, respectively This, I may add, is the only observation of real value made at the time and not automatically recorded that I know of in connection with this shock

At Madras a clock in the office of the Master Attendant, electrically controlled from the astronomical observatory, was stopped at $7h$ $5'$ $45''$ local time, or $7h$ $55'$ $36''$ Port Blair mean time

Port Blair is the only place where any damage was done to masonry buildings, and it is to be regretted that the damage should be so little instructive as is the case The infantry barrack, of which I have drawings showing the damage done, is a long, narrow building situated on the crest of a hill, the major axis bearing N 20° E, while the cross-walls bear E 20° S The latter were severely cracked, while with a single exception not a crack has opened in the longitudinal walls, this might indicate a direction nearly N 20° E, or S 20° W, but

[1] These times differ from those originally given, having been retaken with greater care from the original records The times here and throughout this notice are reduced to Port Blair mean time, and for the sea wave are the time of arrival of the crest of the first wave

is most probably, as will be seen from the sequel, due to their being of less solid construction As regards the angle of emergence the cracks do not indicate much, merely pointing to a nearly horizontal or nearly vertical emergence, the former would be indicated by the fact that a chimney shaft 60 feet high was cracked but not overthrown as it certainly must have been by a severe shock with a moderate angle of emergence, but as this supposition is irreconcileable with the position of the seismic vertical obtained from more trustworthy observations we must suppose the angle of emergence to have been nearly horizontal and the violence of the shock to have been considerably exaggerated

In the Car Nicobar extensive damage was done to the cocoanut groves and huts of the natives, and vents similar to those described in connection with the Cachar earthquake of 1869[1] were opened in the sandy soil It was noted by Major W B Birch, to whose report I am indebted for the facts, that on the margin of the seashore the trees were left standing, while further inland they were overthrown This may have been due to the fact that the edge of the land was protected from the earthquake by the slope of the seaward face being steeper than that of the emergence of the wave but I am inclined to believe that Major Birch's suggestion, that the soil near the sea margin is firmer than that further inland, is more likely to be the true explanation The sea-wave broke on this island and it is recorded that the water penetrated into the houses of the Burmese residents which stood on platforms of less than $2\frac{1}{2}$ feet high, while those on higher platforms escaped

I will now proceed to the discussion of the data available, which are, *firstly*, the records of the arrival of the earth-wave at Calcutta, Madras, False Point, Port Blair, and Kisseraing, and, *secondly*, the records of the arrival of the sea-wave at the stations mentioned above, the latter, however, are owing to irregularities in the depth of the Bay of Bengal of no use in determining the position of the seismic vertical Of the first category, the records from Madras and Calcutta are undoubtedly good, those from Port Blair and False Point are good as far as they go, but only pretend to give the time to the nearest minute, while the fifth is, as will be subsequently shown, unfortunately open to an element of doubt

It has been pointed out by Professor Milne that if the earth-wave arrives at two points on the earth's surface at the same moment of absolute time and a straight line be drawn joining those two points, the seismic vertical should lie somewhere on the line bisecting it at right angles, supposing, that is to say, that the surface of the earth were a plane and its substance homogeneous, on the same suppositions if the time of arrival is known at three stations and circles be drawn round the two at which the arrival was latest with radii equal to the distance traversed by the wave in the respective absolute differences of time between its arrival at those stations and at the first station, and a circle be drawn passing through the first station and touching the circles drawn round the second and third stations, the centre of that circle will represent the position of the seismic vertical Neither of the assumptions are, of course, theoretically correct, but these constructions give a rapid and convenient method of finding the approximate position

[1] Memoirs, G S I, Vol XIX, part I

of the seismic vertical I have, for the purposes of the first construction, taken the time of arrival at Calcutta and Madras as identical and represented it on the map by fine firm lines, the second construction is not represented, but the centres obtained are indicated by dots with the letters C M B for the centre deduced from the Calcutta, Madras, and Port Blair observations, and F M B for that due to those at False Point, Madras, and Port Blair It will be seen that the first-named lies within 30 miles of the true position of the seismic vertical, the error being due almost entirely to the unavoidable distortion of the map, the other shows a greater error, due partly to a less average accuracy of the observations and partly to the fact that the stations are less favourably situated for applying the construction Taking Calcutta, False Point, and Port Blair, we get an impossible centre at the mouth of the Irrawadi, the fact being that this construction is only practically applicable when the three stations form a pretty open triangle The Madras, False Point, and Kisseraing observations give the centre where Major Rogers placed it, but this result is vitiated both by the small inaccuracy of the False Point observation and the greater one at Kisseraing, which will be referred to hereafter

Starting with the C M B centre, a brief investigation proves it to be about 30 miles too far south, so taking Lat 15° Long 89° as the centre provisionally, we find that the geodetic distance from this point to

	Feet
Port Blair is	1,804 475
Calcutta is	3,117,585
False Point is	2,888 620
Madras is	3,177,850
Kisseraing is	3,563,660

Subtracting the distance to Port Blair and dividing the results by the respective differences of time, we get a velocity of transit as between Port Blair and

	Feet per second
Calcutta of	1,957
Madras of	1,948
False Point of	1,807
Kisseraing of	2,666

and as between Calcutta and Madras of 1,746 feet per second—a not impossible result, as the difference of distance would lie mainly in alluvial deposits, though possibly indicates that the centre is about half a mile east of the position assumed

The low velocity as between Port Blair and False Point is easily explicable by the fact that the observations are only given to the nearest minute, had the time interval been 9 minutes instead of 10 minutes, it would give a velocity of 2,001 feet per second, while an interval of $9\frac{3}{4}$ minutes would bring it almost into accord with the Calcutta and Madras observations From this we may conclude that the time recorded at Port Blair is too early, or that at False Point too late, or possibly both It must be borne in mind that the times were taken from the trace left by a pencil on a sheet of paper and on a scale on which it would be difficult to distinguish between, say, 7*h* 53′ 15″ and 7*h* 53′ 45″, though one should be recorded to the nearest minute as 7*h* 53′ and the other as 7*h* 54′

The Kisseraing observation, however, gives a velocity which is inexplicable

on this supposition, and I cannot but consider the error due to an actual error of observation, as, though it can be approximately reconciled with those from the western stations, this can only be done by taking the latter out of accord with each other and giving an inadmissibly high velocity to the whole series The only published record of this observation is that in Major Roger's note, where he says that "at Madras, False Point, and Kisseraing the shock was felt at about the same minute—*7h* 55′ A M," it will be seen that this is rather vague, and a personal application to Major Rogers elicited the fact that the original record had been destroyed, and it was consequently no longer possible to estimate the degree of accuracy of the time record I fear we must reject this observation as of insufficient accuracy for the purposes of the investigation

The position assumed above proves to be that which best reconciles itself to the excellent observations at Calcutta and Madras, and to the automatic records at Port Blair and in a less degree False Point, I shall consequently consider that the shock did originate vertically below a point situated in Lat 15° N, and Long 89° E, and that it travelled with a velocity of 1,950 feet per second, being that indicated by the Madras and Calcutta and Port Blair observations Under these circumstances the time taken by the earth-wave to travel from the seismic vertical to

Port Blair would be	15′ 25″
Calcutta ,,	26′ 39″
Madras ,,	27′ 9″

(I omit Kisseraing and False Point owing to probable inaccuracies of the records)

Subtracting these intervals from the recorded times, we have the Port Blair mean time of the origin of the earthquake deduced from the

Port Blair record as		*7h* 28′ 35″
Calcutta ,, ,,		*7h* 28′ 28″
Madras ,, ,,		*7h* 28′ 27″
	Mean	*7h* 28′ 28″

But as the Port Blair record is liable to an unknown error being merely to the nearest minute, the mean of the Calcutta and Madras results, *viz*, *7h* 28′ 25″, is probably more accurate Taking this result and reckoning back to the various stations we get the true time at

Port Blair,	*7h* 43′ 50″	instead of	*7h* 44′, a probable error of	+10″
False Point,	*7h* 53′ 6″	,,	*7h* 54′ ,, ,,	+54″
Kisseraing,	*7h* 58′ 58″	,,	*7h* 55′ ,, ,,	—3′ 58″

The depth of the focus below the level of the sea cannot unfortunately be ascertained, the only records that could give the angle of emergence being from Port Blair and, as mentioned above, they are indefinite, and all we can say is that the emergence was nearly horizontal, from this we would deduce a focus situated at a small depth, probably about 5 or 10 miles, and being improbably over 15 miles from the surface

In the shape of the area over which the shock was felt there is a notable peculiarity as regards its eastern boundary between Akyab and Tenasserim, which seems to be real and not merely due to insufficient information, for Rangoon and Moulmein are large cities with a considerable resident European population, so

that the shock if felt could hardly have escaped record [1] In the Mergui archipelago it is recorded as slight, and it is very doubtful whether it was felt at Tenasserim. To the south, west, and north the configuration is very different, the shock is recorded as severe at Acheen, it was felt by the ship *Mount Stuart* in N Lat 3° 54′ E Long 91° 21′, to the west it was felt at Calicut, and to the north is said to have been felt at Chunar, though Gaya is possibly the extreme limit This peculiarity may in part be due to a difference in the rocks traversed, but not being fully accounted for in that manner clearly indicates that the shock had its origin in a fissure underlying strongly to the west If we accepted the Chunar record, it would almost be necessary to suppose the fissure curved and bending round from about S-W to S-E, rejecting it we come to the conclusion that this earthquake had its origin in a straight, or nearly straight, fissure bearing about N-W and S-E and underlying to the S-W, a far more probable configuration than the first, and one which is not absolutely incompatible with the Chunar record, if that is correct

When we come to examine the records of the tide gauges the first point to be noticed is the absence of any record from the stations on the Burmese coast, while the wave is shown to have reached points on the western coast of the Bay situated at a greater distance from the centre This, however, ceases to be remarkable when we examine the records from the stations on the delta of the Ganges At Dablat the height of the wave is 12 inches, while at False Point it is but 2 inches, and merely perceptible at Diamond Harbour, if on the delta of the Ganges, exposed to the full force of the wave, the mere shoaling of the waters produced such an effect, it is not surprising that a similar shoaling at the mouth of the Irrawadi should have entirely destroyed the wave already enfeebled by the barrier stretching between Cape Negrais and the Andaman islands

Between the centre and Port Blair the wave must have travelled by a circuitous route, and as it is impossible to say what allowance is to be made for this it becomes impracticable to correctly calculate the rate at which it travelled In all probability the first wave recorded came round the south of the island, while the curve bears ample evidence that the subsequent long-continued and complicated disturbance was due to the interference of the two sets of waves—one travelling from the north, the other from the south

Taking, for convenience of calculation, the time of origin of the wave as 7*h* 28′ 30″, the error so introduced being comparatively insignificant, and in any case certainly not greater than that due to want of accuracy in the records, we find that the mean rate of transit of the wave between the centre and

		Feet per second
Paumben	is	281
Negapatam	„	359
Madras	„	311
Vizagapatam	„	173
False Point	„	213
Dablat	„	104

[1] As this note was passing through the press a paper on 'Earthquake disturbances of the Tides on the coasts of India,' by Lieutenant-General J T Walker, C B, F R S, etc, appeared in 'Nature,' February 14th, in which it is incidentally mentioned that the earthquake w felt at Rangoon and Moulmein

Of these, the difference between the mean rates to Negapatam and Paumben is due to the long stretch of shallow water crossed in the latter case, but the difference between Madras and Negapatam is noticeable, and is probably due to the shallowing of the bay by the deposit in it of the silt brought down by the Kistna and Godavery rivers, this same cause has evidently affected the velocity between the centre and Vizagapatam, while the increase in velocity between the centre and False Point indicates that the wave has travelled over the depression between the two banks caused by the deposit from the Kistna and Godavery on the one hand and the Ganges and Brahmaputra on the other

This notice, besides its direct bearing on the earthquake in question, shows the great value of a few really accurate time observations which, taken in conjunction with such simple observations as are within the power of all to make, have enabled me to fix the position of the seismic vertical, the velocity of transmission of the earth-wave, and the approximate form of the focus, had it originated inland there might not improbably have been sufficient information available to fix the depth of the focus—in the present state of our knowledge, one of the most important, if not the most important point to be determined with some degree of accuracy Under these circumstances it is unfortunate that in the system of seismological observations recently sanctioned by Government an accurate determination of the time could not be incorporated, but with the unskilled even where not unsympathetic observers who are alone, as a rule, available, it would be impossible to secure that accuracy of record which alone would be of use, for this is especially a case where an inaccuracy, where accuracy is looked for, is worse than no record at all

The following facts, though not strictly related to the earthquake under consideration, may with advantage be put on record here

The master of the ship *Commonwealth* reported that he felt three shocks of earthquake on the 1st January 1882 in N Lat 8° 20′, E Long 92° 42′, and that the whole of the Car Nicobar was hidden by smoke Major Birch on his subsequent visit to the island could find no foundation for this statement, so that in all probability it was only the smoke of a fire that was seen

This shock was stated in the daily papers to have been felt at Khatmandu, in Nepal, but to judge from the more detailed information placed at my disposal, this cannot have been the same shock

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On the Microscopic structure *of some* Himalayan granites *and* gneissose granites, *by* COLONEL C A McMAHON, F G S (With a Plate)

In my paper "On the microscopic structure of some Dalhousie rocks,"[1] I have already given an account of the structure of the gneissose granite of Dainkund, Dalhousie This paper is occupied with a description of the "outer band" of gneissose granite at Dalhousie, called gneiss in my previous papers, and of gneissose granite found in the Sutlej valley, and in the Chor mountain near Simla I have also, for the sake of comparison, described the microscopic structure of some

[1] Records, Vol XVI, p 129

undoubtedly eruptive granites, which invade silurian and cambrian (?) rocks in the Ravi and Sutlej valleys

In this paper I propose to follow my usual custom, and begin with a somewhat detailed account of the several specimens, and conclude with some general remarks by way of summing up the results of my investigation

1 Granite intrusive in the schists above Darwás, from a dyke on the road between Darwás and Kilar, Pángi valley, Chamba [1] The hand specimen shows the junction of the granite and the mica schists A parallelism of structure, evidently due to traction, is, to a certain extent, observable in the granite Schorl is abundant in the hand specimen, but none occurs in the slice

M —Quartz, orthoclase, and a silvery mica, are abundant, and there is a little triclinic felspar

The quartz is hyaline, and contains a prodigious number of liquid cavities Most of the orthoclase is white and opaque The slice contains a large garnet of decidedly pink colour in transmitted light, part of it is decomposed There are several belonites, but they do not contain any shrinkage cavities

Viewed macroscopically, the mica is of a brilliant silvery metallic lustre, but under the microscope it is dull, and shows no colours under the polariscope

Nos 2, 3, and 4 —Granite intrusive in quartzite and in schistose rocks at Leo, on the Spiti river It occurs in dykes and veins varying in thickness from 30 feet to a fraction of an inch, and penetrates the rocks in all directions (See Records, Vol XII, p 60)

2 A fine-grained granite

3 A medium-grained granite Muscovite having a brilliant silvery lustre is very prominent Schorl is not visible to the naked eye The felspar is of dull white colour, differing little in tint from the quartz A pink garnet is visible in the hand specimen

4 A fine-grained granite Scarcely any muscovite is to be seen with a lens, but well-crystallised minute prisms of schorl are very abundant, and give the rock a speckled appearance

M —The quartz in these specimens is almost wholly of polysynthetic structure, similar to the "fish roe" quartz of the Dalhousie gneissose granite It contains liquid cavities with movable bubbles, though not in great abundance

Orthoclase and plagioclase are both present, and, apparently, in nearly equal quantities The twinning is very fine, the lamellæ being extremely thin. In some crystals they are slightly curved out of the perpendicular, in other felspars cracks have been formed subsequent to the twinning, and have been filled with quartz, whilst in one instance the twinning has been faulted by a diagonal fracture All these circumstances seem to indicate conditions of strain connected with the intrusion of the granite into the sedimentary rocks

Muscovite is abundant in all the specimens, and in all it polarizes in delicate colours, but with extreme brilliancy, as in the Dalhousie gneissose granite All the slices contain schorl, garnets, and a little green mica In No 3, the schorl and garnets are in strings, having a common direction, the result doubtless of traction The garnets contain enclosures with fixed bubbles, and one of the en-

[1] Records, Vol XIV, p 308

closures is apparently a "stone cavity." Quartz enclosures are common in the schorl.

Neither magnetite nor ilmenite is present, but red ferruginous stains are not uncommon.

Nos. 5 to 12.—Granite from the cliffs above Jángí, Sutlej valley. I have described the mode in which the granite occurs in previous papers (Records, Vol. X, p. 221; Vol. XII, p. 57). The result of its study in the field on two occasions left no doubt in my mind of its intrusive character. The rock is white and fine-grained, and is composed of quartz, felspar, and biotite.

M.—Quartz is more abundant than felspar, but not notably so. Plagioclase is sparse, and is very subordinate to the orthoclase. All the slices contain microcline, except No. 7.

Garnets are present, but they are very small; some of them contain liquid cavities with extremely minute movable bubbles.

Biotite is plentiful; it occurs in large groups, in which the folia are oriented in all directions and the basal cleavage is strongly developed, and also in the form of minute rounded or hexagonal-shaped microliths scattered abundantly through the ground mass. Elongated microliths of it are also present, but they are not so numerous. It is of rich brown green and green-brown colour in transmitted, and deep black in reflected, light.

Except in the form of microliths, muscovite is extremely scarce. The only piece of any size occurs imbedded in a group of biotite. Thousands of microliths of this mica are crowded together in many of the felspars in a way exactly similar to that described in my paper on the gneissose granites of Dalhousie.[1] At times, they are scattered about in a promiscuous manner; at others, they conform to the direction of the cleavage planes of the felspar.

In the slices of the Jángi granite under consideration, and in the gneissose granite of the Sutlej valley generally, these muscovite microliths—for such I take them to be—frequently assume very curious combinations, imitative or suggestive of organic structures, the result, I apprehend, of the imperfect development or arrested crystallisation of these microliths. At fig. 9 I have sketched a dendritic combination that occurs in one of the slices.

At fig. 10 I have given a sketch of crystals formed within a crystal ("stone enclosure") with a contraction bubble, due to shrinkage on cooling. This illustration is taken from slice No. 8. As the Jangi granite is undoubtedly an eruptive rock intrusive in the schists in which it occurs, it is interesting to compare the enclosures contained in it with those of rocks whose eruptive character is more doubtful.

Figs. 11, 12, and 13 are sketches of microscopic crystals (greatly enlarged) found in slice No. 7, which are typical of the kinds of enclosures not uncommon in the granites and gneissose granites of the Sutlej valley. No. 11 contains numerous cavities with contraction bubbles in them. No. 12 encloses stone cavities, or crystals, with bubbles in them, and gas cavities; whilst No. 13 contains cavities and crystals, one of the former of which holds a nearly rectangular crystal. The crack observable in No. 11 is probably due to shrinkage on cooling. Enclo-

[1] Records, Vol. XVI, p. 131.

sures, such as those depicted, are characteristic of igneous rocks, they show that the mass which contains them was subjected to great heat and was reduced to a more or less fluid or plastic condition, that the crystals under observation contracted on cooling, and that they either caught up the micro-crystals and the fluids and gasses now enclosed in them in the act of crystallisation, or that the mineral matter at the time of consolidation deposited these endo-crystals, and the fluid and gas, held in solution, or occluded in it, when at a high temperature

No 13 —Granite from a dyke near Rarang, Sutlej valley This dyke (Records, Vol X, p 221) is about 300 or 400 feet wide, and cuts through thin-bedded mica schists up to the crest of the ridge, sending out large lateral veins into the schists It is a very fine grained rock, of much darker colour than the last, owing to the abundance of biotite present in it The felspar is very glassy looking, and much resembles quartz in colour and aspect A parallelism in the arrangement of the biotite, resembling incipient foliation, is, to a certain extent, observable

M —Quartz predominates over the felspar, and orthoclase is very subordinate to plagioclase The slice contains no muscovite, except in the form of microliths There are a few small garnets In general characteristics this rock much resembles the Jángi granite, and doubtless it is only a variety of it

The quartz contains numerous liquid cavities The great majority of them are without bubbles, others have fixed bubbles and some few movable bubbles A flattened variety of liquid cavity, with a fixed bubble, is common

Several of the microliths have elongated shrinkage cavities or bubbles

No 14 —Granite from the centre of a dyke intrusive in mica schists at Pángi, Sutlej valley[1] A fine-grained white granite, containing white felspar quartz, muscovite, biotite, and schorl The muscovite is in hexagonal-shaped packets

M —Quartz is decidedly subordinate to felspar, plagioclase to orthoclase, and biotite to muscovite Schorl and garnets are present The muscovite is well crystallised and is in hexagonal plates The cleavage of both muscovite and biotite is strongly developed, and some of the biotite is enclosed in muscovite

The felspar is free from microliths of muscovite and biotite A little microcline is present

One of the garnets—or what I doubt not is a garnet—exhibits double refraction It is colourless in transmitted light, and is evidently unaltered, so that the double refraction is not due to alteration The garnet is also too large, and the slice is too thin to admit of the supposition that the section of the mineral under examination is superimposed on a slice of quartz or felspar, so its abnormal behaviour between crossed nicols cannot be attributed to the intervention of a doubly refractive medium I have sometimes observed the peculiarity now noted in garnets in the gneissose granites, though the double refraction is usually very feeble

One variety of garnet, colophonite, is said to exhibit double refraction, and, *vide* E S Dana's Appendix III, page 50, garnets are considered pseudo-isometric, and are referred to the triclinic system by Mallard and Bertrand But may not

[1] Records, Vol X, p 221

the occasional and generally very feeble double refraction of some of the garnets of the granites and gneissose granites of the North-West Himalayas be due to strain and be simply one of the results of pressure consequent on intrusion? It is well known that glass subjected to strain exhibits double refraction.

Liquid cavities, with fixed and movable bubbles, are abundant. The bubbles are of good size, and for the most part cover about half the area of the cavity, indicating a condition of very great heat and great subsequent contraction on cooling. The whole aspect of the rock shows that the granite, when injected into the schists, was in a completely fused or fluid condition, and cooled slowly, hence the perfectly crystalline condition of its component minerals.

No. 15.—Granite from another large dyke. Pángi, Bassáhir. Similar dykes are rather numerous in the gneissose granite between Wangtu and Pángi. Muscovite is plentiful, and a dark-green mica is rather abundant. Schorl is present in some quantity. The felspar assumes a green appearance here and there, owing apparently to the deposit of a thin superficial film of chlorite.

M.—Orthoclase is more abundant than quartz. Plagioclase is present, but in very small quantity. The double refraction of the muscovite is so great that the thinnest sections of it only show the feeblest colours in polarized light. The basal cleavage lines of the green mica are well developed in some sections. Mica is not present in the form of microliths.

Liquid cavities with movable bubbles are extremely numerous both in the quartz and in the felspar. As in the last specimen, the bubbles are large relatively to the size of the cavities, and they are remarkably lively. Much of the felspar is opaque owing to the abundance of the enclosures in it, partly liquid and partly unresolvable ones. The slice contains gas cavities, but they are not abundant. I cannot call to mind any rock in which liquid cavities are more abundant than in this specimen. I have not observed a single microlith in this slice.

As in the last rock described, this granite was evidently subjected to intense heat, and reduced by igneo-aqueous action to a fused condition and subsequently cooled slowly.

Nos. 16 to 19.—Gneissose granite. Wangtu[1]: Sutlej valley, Bassáhir. These specimens contain an abundance of very black biotite, in the arrangement of which parallelism of structure is very distinct.

M.—In these slices orthoclase largely predominates over the plagioclase; whilst quartz and felspar are present in about equal proportions. Biotite and muscovite are both present; the former predominates in leaves of other than microscopic size, but the muscovite is abundant in micro-crystalline agglomerations in the form of microliths in the felspar, as described in the Jángi granite, slices 5—8.

The dendritic combinations described in connection with the Jángi granite occur in these slices, and fig. 9 is taken from one of them.

The quartz in these slices occurs in grains of moderate size, and also in fish roe grains, the latter showing a decided tendency to assume hexagonal outlines.

[1] A brief allusion to the rocks at Wangtu is contained in my paper in the 10th Volume of Records, pp. 218, 219.

The quartz contains numerous liquid cavities with bubbles, some of which are movable Much of the felspar is very opaque, but in some the intersection of the basal and clino-diagonal cleavage planes is well seen

This rock has all the appearance under the microscope of an ordinary granite of eruptive origin

Nos 20 and 21 —Granite from the neighbourhood of Wangtu

M —Plagioclase is the predominating felspar, though orthoclase is also present

Microcline is abundant and is of typical character In slice No 14 one of the crystals is of large size The orthoclase and microcline taken together, equal, or nearly equal, the plagioclase

Schorl is abundant, and contains numerous inclusions of quartz Biotite and muscovite are present, but in small quantities The quartz is very subordinate in amount to the felspar

Liquid cavities with movable bubbles abound in the quartz, and I have observed some with fixed bubbles in the felspar The bubbles are of good size, and the area of the cavities appears, at a rough guess, to be about two and a half times that of the bubbles contained in them

The quartz enclosed in the schorl contains liquid cavities with movable bubbles, whilst the schorl itself contains cavities with fixed bubbles There are some microliths containing what appear to be shrinkage cavities in them

Beryl from a granite dyke near Wangtu, Sutlej Valley —I have beryl taken from a granite dyke which is intrusive in the gneissose granite at Wangtu enclosed in quartz, in felspar, and in muscovite, and it is therefore clear that beryl was the first mineral to crystallise An examination of thin slices of the beryl under the microscope is particularly interesting, as it enables us to ascertain the condition of the fused mass at an early stage of cooling before the quartz, felspar, and muscovite had begun to crystallise

The examination of these slices shows that the magma must have been in a fluid state, and that a considerable amount of heated gas, water, and carbon dioxide were intimately blended with it in a superheated condition when the beryl crystallised

The number of enclosures containing bubbles to be seen in these slices is quite extraordinary The enclosures are of various shapes, some are hexagonal, others are more or less round or of very irregular shapes The bubbles, as a rule, occupy about half the area of the cavities which contain them Some of the bubbles are movable, but the great majority of them are stationary. Many of the lacunæ are full of liquid, whilst others contain gas, which in many cases has contracted on cooling Some liquid cavities contain globules of liquid carbon dioxide with enclosed vacuum bubbles—bubbles within bubbles—the inner bubbles being movable and in some cases remarkably lively There seems to be no doubt of the larger bubble being carbon dioxide, as the inner bubble disappears when a piece of heated iron is brought near it and re-appears on cooling

The beryl also contains some good "stone cavities" with fixed bubbles, that is to say, enclosures in which a stony base has deposited crystalline matter on cooling

Nos. 22 to 25 —Gneissose granite at Chora between Sarhan and Taranda, Sutlej valley The extreme whiteness of the felspar is in strong contrast with the

blackness of the biotite, which is abundant A parallelism of structure in the arrangement of the biotite is, to a certain extent, observable in the hand specimen

M —Orthoclase and quartz are probably about equal in amount, plagioclase is also present, but is subordinate, schorl is very abundant, it is in large irregularly shaped pieces, and encloses rather large grains of quartz The slice also contains muscovite, biotite, and garnet. The biotite and muscovite are for the most part linked together in tortuous strings, leaves of the one occasionally alternating with the other species of mica micro-garnets, and rounded microliths of biotite are scattered rather freely through the slice

Gas cavities are abundant, and there are good liquid cavities with movable bubbles The flat type of liquid cavities is also common

The slice contains numerous stone enclosures that have deposited dusty matter on cooling One of these, depicted at figure 5, has been fractured, the fractures being probably due to contraction on cooling, and the subsequent dislocation to a tremulous movement of the viscid matrix In other cases, instances of which are depicted at figures 6 and 7, these stone enclosures, or crystals, have either deposited minute endo-crystals on cooling, or have in the process of their own crystallisation caught up previously formed microliths and held them in their embrace during consolidation

In either case, the instances illustrated at figs 5, 6, and 7 show that the rock was, at one stage in its history, in a more or less liquid or fused condition

At fig 8 I have given another illustration from those slices, in which minute crystals are contained in another crystal, which is itself caught up in, or was deposited from, a stone enclosure

The size of the bubbles in the liquid lacunæ relatively to the area of the cavities varies considerably, but I should think on the average the cavities cover an area of from two and a half to three times that of the bubbles

Nos 26 to 30 —Gneissose granite between Kalog and Báli, Sutlej valley On the high level road, now fallen to ruin, between Nakanda and Rámpur

M —These slices contain some cavities that have deposited stony material, enclosures with fixed bubbles in them and microliths that contain cracks which have evidently resulted from shrinkage on cooling

Nos 31 to 33 —Gneissose granite from the Kot peak above the Bági road, described at Vol X, p 217, Records

M —This rock has all the appearance of a true granite under the microscope Orthoclase and plagioclase are both present—the latter in some abundance Biotite and muscovite are plentiful Quartz is subordinate to the felspar

Muscovite is present in the form of well-cleaved folia and also as microliths, the latter being very abundant Biotite also occurs in large microscopic leaves grouped together, and in small rounded isolated ones of microscopic size scattered through the ground mass

Long, attenuated, colourless microliths, often bent and broken, are present in considerable abundance, and appear to be imperfectly developed apatite

Opacite occurs in some quantity, sometimes it is attached to microliths and at others is caught up inside them, in both cases being very similar to those described in my paper on the lavas of Aden See figs 4, 6, 11, 12, and 13 of the plate illustrating that paper Records, Vol XVI, p 158

Some microliths contain what appear to be shrinkage cavities and enclosed micro-crystals. One of the former is undoubtedly due to shrinkage on cooling, as it runs the length of the microlith and conforms to its shape. The illustration given at (*a*) of fig. 11 of the last-quoted paper applies equally to the microliths now described.

The quartz contains liquid cavities with movable bubbles, but they are not very abundant. It also contains elongated prismatic enclosures that have deposited dusty matter on cooling.

Slice 23 contains some minute prisms of schorl and some hæmatite or gothite.

Nos. 34 to 50.—Gneissose granite, Bági road. All that needs to be noted regarding these specimens is that they contain liquid cavities with movable bubbles, numerous microliths with fixed bubbles and elongated shrinkage cavities, running with the length of the microlith, and microliths cracked through shrinkage and fractured owing to a tremulous movement in the viscid matrix. These microliths have either caught up opacite at the time of formation or have deposited it on cooling, and they have opacite granules attached to them, in both cases resembling those described under Nos. 31 to 33, and which have been compared with similar bodies in the Aden lavas.

No. 51.—A dark porphyritic gneiss, from the flank of Hattu, between Hattu and Nakanda. There is a small outcrop at about the same elevation as the Nakanda travellers' bungalow. The gneiss contains small felspar "eyes" and large rectangular crystals of orthoclase.

M.—This is, I think, a metamorphic rock. It is composed of quartz in minute granules, orthoclase, a few crystals of plagioclase, and countless leaves of a dark greenish-brown mica. There is complete parallelism of structure, and all the leaves of mica not only point in the same direction, but their optical orientation is perfectly homogeneous, and when the slice is revolved under a single nicol, extinction is simultaneous in all the leaves.

Some colourless mica and some garnets are present, and countless crystals and granules of epidote. There are no liquid cavities with bubbles.

Nos. 52 and 53.—From the summit of Hattu. These specimens would, if their macroscopical appearance alone were considered, be classed as ordinary and very typical gneiss.

The felspar is present in the form of eyes, and in elongated masses or strings of eyes, and occasionally in more rectangular crystals. Many of the eyes exhibit carlsbad twinning, the twinning plane coinciding with the longest diameter of the eye. The matrix is strongly foliated, lines of dark mica curving round the felspar crystals. The cleavage planes of the rock sparkle with minute facets of mica.

M.—Quartz predominates over the felspar and plagioclase is sparse. A large crystal of orthoclase is twinned on the carlsbad type, and in one twin an intergrowth of plagioclase has taken place.

The leaves of muscovite and biotite exhibit a strong tendency to arrange themselves in strings which flow round the porphyritic crystals. The leaves of biotite and muscovite in these chains often alternate with each other, at other

[1] Records, Vol. X, p. 217.

times part of a string is formed of leaves of biotite linked together, and the other portion of leaves of muscovite combined together The leaves do not all follow each other in straight lines, but some radiate from the chain at high angles to it. Extinction does not take place simultaneously in all the leaves of biotite as in No 51, but the greater proportion of the leaves in the field of the microscope extinguish together

The mica is not confined to these strings, but is also scattered promiscuously through the slice, and there are many rounded and elongated microliths of biotite in the slice Some other colourless microliths are also present, but they are not numerous

The quartz is in minute grains, and a general parallelism in the arrangement of these grains is distinctly observable Flat liquid cavities, with fixed bubbles, are rather numerous

Liquid cavities, with movable bubbles, are abundant in some grains, but not in others

Dendritical muscovite is plentiful in one of these slices

Slice No 52 contains some small colourless garnets

I think this specimen is an ordinary gneiss

Nos 54 to 59 —Granite from the summit of the Chor mountain A medium-grained granite, containing quartz, felspar, a dark mica, schorl, and some small garnets Some of the larger orthoclase crystals are seen to be macled on the carlsbad type The rock has a speckled appearance owing to the superficial decomposition of some of the felspar

M —It is not possible to determine the relative proportion of quartz to felspar from mere inspection, for in some slices quartz preponderates and in others felspar A macroscopical examination of the hand specimen, moreover, does not enable me to decide the question On the whole, I think, quartz and felspar are pretty equally divided

Plagioclase is present in some abundance, but it is decidedly subordinate to orthoclase

Fibrous felspar is to be seen in one of the slices, and it shades here and there into typical microcline

Orthoclase is occasionally seen to be twinned on the carlsbad type, and one crystal of this mineral encloses a small prism of orthoclase macled on this system

Muscovite is very sparse except in the form of microliths, but these are so abundant in some of the felspars as to make it almost impossible to say whether the latter are monoclinic or triclinic Some cryptocrystalline mica is also present

The biotite, in transmitted light, is of pale greenish-brown colour in sections that display the basal cleavage, whilst sections which coincide with the cleavage, *viz*, those normal to the optic axis, are of deep rich reddish-brown

Garnets, colourless in transmitted light, are rather numerous They are for the most part of good size, and frequently present regular crystallographic outlines The larger ones generally present six-sided sections, whilst some of the minute ones appear to be in the form depicted in figs 241, 242, and 246, page 266, J D Dana's System of Mineralogy, *5th edition*

Some of the slices contain patches of chloritic matter, which appears to be a secondary product resulting from the alteration of garnet. One patch is four-sided, the sides being straight lines, and is doubtless a pseudomorph after garnet; whilst, in other cases, small groups of garnets, some of which are in process of alteration, are embedded in chloritic matter, which, it seems probable, was formed from the degradation of some of the members of these groups. One of the garnets exhibits a feeble double refraction.

The slice is stained here and there with ferric oxide apparently derived from the biotite, and this imparts rather a pink appearance to the rock viewed macroscopically.

Two of the slices contain grains of magnetite either caught up in or adjoining leaves of biotite. I have several times seen the presence of magnetite fringing biotite or hornblende attributed to the decomposition of these minerals, but I do not think there are any grounds for supposing that the magnetite has been derived from the biotite in this case, for the grains of the former are of considerable size and the biotite exhibits no signs of alteration in their neighbourhood. I think the biotite was attracted to the magnetite, by molecular attraction, at the time of crytallisation and formed upon it. Magnetic attraction even might come into play between magnetite and a mineral so rich in iron as biotite.[1] In some specimens (J. D. Dana) the percentage rises as high as 26.9.

One piece of felspar contains a large prism of quartz with pyramidal terminations. The felspar itself is a very peculiar object. It is traversed in parts by irregular straight lines running in one direction that polarise in a different tint to the body of the felspar. They are very fine lines with rather jagged sides, and they want the regularity of plagioclase twinning. Some of them are long and some of them are short, some bifurcate towards their termination, others inosculate with each other. These lines are traversed at a low angle by another set of larger and still more irregular lines, or veins, which here and there merge into the first set. The second set of lines is filled in part with cryptocrystalline mica, and in part with felspar. At their terminal ends they merge into patches of cryptocrystalline or dendritic mica. It is difficult to say whether the two sets of lines are due to intergrowth, or to cracks formed along intersecting cleavage lines before the whole of the mineral constituents of the rock had completely consolidated. Such cracking might easily occur in a viscoid or partially consolidated rock subjected to great strain in the course of intrusion into hard stratified rocks, and I think the appearances above described are probably due to this cause. Other felspars appear also to have been cracked, and filled with a confusedly crystalline material which seems to be in part micaceous.

The quartz is in large and also in microscopic grains; liquid cavities with movable bubbles are not numerous, and they are of minute size; cavities with fixed bubbles containing a coloured liquid, or glass, are not uncommon. Hair-like belonites are numerous in the quartz.

"Stone enclosures," or microliths, that have deposited minerals on cooling, occur in these slices. A sketch of one is given at fig. 1. The crystal deposited

[1] Electro-magnets are now used in chemical laboratories to separate minerals rich in iron from those poor in iron.

at (*a*) has curved sides suggestive of siderite Other crystals have been had deposited at (*b*) The microlith has cracked in two places, probably the result of contraction on cooling, and one crack has resulted, apparently, in its division into two pieces

At figs 2, 3, and 4, I have depicted illustrations, taken from these slices, of opacite (apparently magnetite) deposited in cavities It is difficult to say whether the opacite was deposited on cooling from a glass which, when under high pressure, at a great heat, held it in suspension, or whether the glass was attracted to the opacite Figs 2 and 3 seem to me instances of the former, but whichever explanation be the true one, in either case the rock must have been in a fluid or semi-fluid state, and cases such as those depicted in figs 1 to 4 seem to indicate that the rock, before consolidation, was in a condition of *aqueo-igneous* fusion

No 60—From the crest of the ridge of the Chor mountain above Barela This is seen to be composed of quartz, felspar, and black mica (biotite) Some of the felspars are in large porphyritic crystals The mica is embedded in the felspar and quartz, but it principally flows in streams round the felspar crystals and gives a gneissic aspect to the rock

M—The quartz is in small grains with the meandering irregular outlines characteristic of the quartz of granite It is also present in the form of micro-crystals Orthoclase is abundant and the slice contains a large carlsbad twin Plagioclase is plentiful, but it is very subordinate to the orthoclase Biotite is abundant in large and in micro leaves Muscovite is present, but sparsely so Rounded garnets are numerous and one of them is embedded in biotite

A cluster of epidote grains occurs in a triclinic felspar, and a few other grains are scattered about in the slice

The felspar alluded to contains multitudes of microliths, some long and hair-like, others of somewhat stout build Some of them apparently deposited mineral matter on cooling Fig 21 is an illustration of one of them

The quartz contains numerous liquid cavities with good-sized bubbles I have not observed movement in any of them Gas cavities are not uncommon, and enclosures containing a coloured liquid, or glass, with fixed bubbles, similar to those in the specimen from the top of the Chor, occur in this slice also

Nos 61 and 62—A felspathic schist from the vicinity of Barela The specimen was taken from a bed below the outcrop of the gneissose granite

M—Under the microscope this specimen resembles a micro-gneiss. Grains, or eyes of felspar and quartz, are arranged in approximately parallel lines, the intervals between them being filled up with micro-grains of quartz and minute leaves of a brown-green mica The felspar is principally orthoclase—a little of it is plagioclase In one slice the felspar and quartz are eye-shaped, in the other they have the appearance of sub-angular and rounded grains

The mica is in minute leaves No basal cleavage is anywhere to be seen, and in one slide it is only dichroic here and there, showing that the leaves are all turned one way so as to present axial sections

This is unquestionably a clastic rock, though whether it is a micro-gneiss, properly speaking, or whether it is a somewhat altered sandstone, made up of granitic or gneissic materials, is more difficult to determine

The quartz is not at all hyaline, and I have detected no liquid cavities in it

No 63.—From the Chor mountain near Talichog This is a very dark specimen owing to the abundance of black mica The hand specimen contains rectangular porphyritic crystals of felspar, one of which is $2\frac{5}{8}$ inches long by $1\frac{1}{4}$ inches wide Two adjoining ones are twinned In one or two places the quartz and biotite have formed streaky-looking combinations

M.—This generally resembles No 60 from Barela Orthoclase predominates over plagioclase, and felspar over quartz Garnets are numerous, and epidote is more abundant than in No 60 Both occur enclosed in biotite and also separately

Epidote is commonly found in syenite, and it is supposed to be the alteration product of hornblende I have not as yet found any hornblende in these rocks

There are nests of colourless microliths, some of which may be apatite, cracks, apparently due to shrinkage, are very common in them Some few have deposited mineral matter on cooling, or have caught up such matter in the act of consolidation

Liquid cavities with movable bubbles are sparse

The outer band at Dalhousie

The following specimens were examined, namely —

- Nos 1, 2, 3, 4, 5, and 6, from the neighbourhood of Bagrár (Bagraur), from the vicinity of Banatu (trans-Ravi), and from the ascent between Sherpur (Sairpur) and Dalhousie
- Nos 7, 8, and 9, from the cart road near Dunhára (Damara)
- Nos 10, 11, and 12, from below Bátri (Rampur of the map)
- Nos 13 and 14 from Chuári (Chaohari)

Viewed macroscopically, Nos 1 to 6 and 10 and 11 would be classed as streaky gneisses, 7, 8, 9, and 12, as gneiss verging towards the granitoid type 13 and 14 are porphyritic gneisses, inclining towards granitoid gneiss The porphyritic crystals are rectangular, and are oriented at varying angles to the line of pseudo-foliation

I now proceed to give an account of the structure of these specimens as exhibited by thin slices under the microscope

All the specimens contain quartz In some slices the quartz predominates over the felspar, in others the latter is in the ascendancy On the whole, quartz is probably somewhat more abundant than felspar

Nearly all the quartz is in the form of fish roe grains, similar to that described in my paper on the gneissose-granite of Dalhousie It meanders through the slice in strings, and fills cracks in felspar crystals The grains are extremely minute and frequently show a tendency to hexagonal outlines

Orthoclase is present in all the slices, and microcline is observable in slices Nos 8, 10, 12, 13, and 14, being plentiful in No 12, but not abundant in the others

Plagioclase is absent in Nos 2, 4, and 6, plentiful in No 12, but sparse in the remaining slices Orthoclase, therefore, largely predominates over triclinic felspar

Biotite is present in Nos 7, 8, 9, 10, 11, 13, and 14, and a mica, dark green in transmitted light, that is probably biotite, is present in the rest

Muscovite is present in all the slices, and it occurs both in its foliated form and as microliths. In No. 4, the latter are so abundant in some of the felspars as to nearly overpower the felspathic element and to give the felspars superficially a micro-felsitic aspect.

Cryptocrystalline mica occurs in all the specimens, and is plentiful in some slices. It is drawn out into strings, and meanders about in a stream-like course, in the manner described in my paper on the gneissose granite of Dalhousie.

Magnetite, ferrite, and garnets, are to be found in all; whilst schorl is abundant in No. 12, but absent from the other slices.

Liquid cavities with movable bubbles are present in all, except Nos. 8, 9, 10, and 11. They are of good size in Nos. 4 and 5, but are generally very minute in the remaining slices. They are very numerous in Nos. 4, 5, 7, 12, and 14, but are somewhat sparse in the others. In No. 12 they are not only abundant in the quartz, but are almost equally so in the felspar and schorl: a large garnet is also full of them. The cavities and bubbles in the schorl and garnet are relatively much larger than those in the quartz and felspar, and would seem to indicate that the schorl and garnet crystallised at an earlier stage of consolidation of the rock than the felspar and quartz. In this slice, even a microlith of muscovite contains liquid cavities with movable bubbles. In No. 14 a microlith contains seven cavities with fixed bubbles, which appear to be liquid cavities. If these are glass cavities, they would afford a strong argument in favour of the igneous origin of the rock; but even on the supposition that they are liquid cavities, the presence of numerous liquid cavities crowded into a minute microlith indicates that, when the latter consolidated, the rock must have been in a fused or plastic condition, and the intermixture of super-heated water or steam with the mineral constituents of the rock most intimate. We have already seen that when the beryl of the Wangtu eruptive granite crystallised, the granite was in a similar condition. A sketch of this microlith (much enlarged) is given at fig. 20. It reminds one very much of the microlith figured at fig. 11, taken from Jángi granite. Air or gas enclosures are present in all the slices, and are sometimes abundant.

I now proceed to note some points of special interest observed in the several slices.

In No. 1, the twinning planes of the plagioclase are sometimes very much bent out of the perpendicular, showing that they were subjected to considerable strain between the time of their crystallisation and their attainment of perfect rigidity. A similar feature is observable in some of the other slices.

At fig. 15 (*a*) I have given a sketch of a crumpled mica seen in slice No. 7, which appears to have been doubled up after crystallisation, whilst the laminæ were still pliant, in the manner described in my paper on the gneissose granite of Dalhousie (see fig. 4, plate II, of that paper). In that paper, I attributed the crumpling to traction.

The mica is muscovite, (*a*) the substance in which it is embedded is a structureless, whitish, opaque substance, analogous to leucoxene. (*b*), in the illustration, is the termination of a long string of fish roe quartz.

At fig. 14 I have given a sketch, taken from slice No. 1, in illustration of a peculiarity characteristic of these rocks; (*a*) is a narrow stream of leucoxene,

or allied substance, white in reflected, but perfectly opaque in transmitted, light The dark line (*b*) that runs along the lower border of the leucoxene is red ferrite (*c*) is a train of magnetite, or ilmenite grains, in the stream of leucoxene and (*d*) is a garnet The ferrite, it will be observed, does not come into contact with the grains of magnetite or ilmenite I do not think that the leucoxene has been produced by the decomposition, *in situ*, of the iron grains, for several reasons In the first place, the grains of magnetite do not show any trace of decomposition along their edges, but are perfectly fresh throughout Secondly, grains of magnetite are to be seen in other places quite unconnected with the leucoxene, whilst streams of the latter substance are common between which and the iron no direct connection can be traced The ferrite, on the other hand, is often directly connected with magnetite The explanation of the above facts appears to me to be as follows when the plastic rock was at rest, the acid and aqueous vapours contained in it began to act on the iron, and leucoxene was formed by the action of the former on the ilmenite, and ferrite by the action of the latter on the magnetite Motion succeeded to the temporary rest, and then the leucoxene and ferrite were, under the influence of traction, drawn out into strings in which the undissolved fragments of ilmenite and magnetite were frequently entangled

This explanation, of course, involves the supposition that the iron first crystallised and was afterwards acted on by the corroding action of acid vapours contained in the rock, but this suggestion will present no difficulty to those who have studied, under the microscope, such volcanic rocks as the dolerite of Auvergne, in which the corroding action of vapours on some of the minerals contained in the lava is frequently to be observed

Since writing the above lines, I have come across an interesting remark regarding ferrite in Mr J J Harris Teall's Cheviot Andesites and Porphyrites (Geological Magazine, Decade II, Vol X, p. 257) In describing a porphyrite showing "well-marked fluidal structure," he remarks "The ferrite is especially abundant in fluidal bands and stripes which curve round the larger crystals in a very characteristic manner Vogelsang describes a similar distribution of ferrite in certain of the Hungarian quartz-trachytes"

The above fact that ferrite has been observed drawn out in "fluidal bands and stripes" in true lavas by competent observers, affords an important confirmation of the conclusion I independently arrived at regarding the origin and significance of the ferrite "bands and stripes" in the rock under consideration

The felspars (orthoclase) in these slices sometimes contain intergrowths after the manner of perthite In some cases the mineral intergrown with it is felspar, at other times quartz

Cracks in felspars filled up with fish roe quartz are very common, whilst occasionally the latter appears to be the residuum, left in pools, so to speak, in the interior of felspars, after the separation of the alumina and the other constituents of the felspar

At fig 16 I have given a sketch, taken from slice No 6, of what appears to have been a large felspar, cracked and split into pieces and then pushed over like books on a shelf by pressure and traction At any rate the outlines certainly suggest this idea The cracks are filled partly with fish roe quartz, but principally by cryptocrystalline mica The dark portion at the bottom

consists of dark micaceous, imperfectly crystallised matter, running in ropy lines through the slice The several pieces of felspar shown in the sketch are all in optical continuity with each other, and appear to be fragments of one crystal

At fig 18 I have represented a minute stone cavity, found in slice No 6, in which crystalline matter has been deposited on cooling The upper mineral has a distinctly hexagonal form, whilst the lower mass seems to be an agglomeration of stony matter rather than one crystal. Forms such as these show distinctly that the mass in which they are found was reduced to a fused or plastic condition by heat

At fig 17 I have depicted a cavity, seen in the same slice (No 6), which contains a large air-bubble The cavity was evidently once filled with air, to the expansive power of which the formation of the cavity is due, but the air contracted on cooling to its present size The bubble, as will be seen in the sketch, seems to be a little too wide for the cavity, this appearance, however, is simply due to refraction, the empty portion of the cavity acting on the light passing through the mineral differently from the bubble of air

Fig 19 is another illustration of the same kind taken from slice No 12 The cavity is in a schorl crystal, and contains air or gas that has contracted on cooling The bubble does not contain the central transparency usually seen in air bubbles, but it shines brilliantly in reflected light like an air or gas bubble

These cavities and contained air or gas bubbles—and they are by no means the only examples of the same kind contained in the slices under description—afford evidence to show that these rocks were subjected to sufficient heat to reduce them to a plastic condition The bubbles on cooling appear to have contracted to about half their original size, from which I infer that the rock was raised to a high temperature The fact that the cavities themselves are not circular, is explained by the fact that their shape is controlled by extraneous forces, and among others the crystallographic energy of the molecules of the mineral in which the cavity is formed, air or gas caught up by a mineral in the act of crystallisation would expand, not equally in all directions, but along the lines of least resistance which would usually coincide with the cleavage planes of the crystallising mineral

Conclusion —The rock specimens described in this paper come from an extended area The first is that of granite intrusive in mica schists above Darwás, in the Pangi valley of Chamba, the next is granite intrusive in the schists at Leo, on the Spiti river Other specimens are from the cliffs above Jángi, in Bassáhir, on the Upper Sutlej, and from dykes at and near Rarang and Pángi, in Bassáhir [1]

There can be no doubt whatever of the eruptive character of these granites, for they are seen in the field to cut across the schists, and in some cases to penetrate them in all directions I thought, therefore, that they would be good rocks to compare with the gneissose granites of neighbouring regions

Following the line of the Sutlej river, I collected my other specimens at Wangtu, at Chora, at the Kot peak and the Bági road, at Báli, and at the Hattu mountain above Nákanda, in the neighbourhood of Simla I then passed to the

[1] Chamba Pángi is on the River Ravi, Bassáhir Pángi is on the Sutlej

Chor, a prominent mountain abutting on the plains , and, finally, I came to the outer band of gneissose granite at Dalhousie

The granite from the dyke that bursts across the schists above Darwás (slice 1) is interesting, from the fact that, when viewed macroscopically, it exhibits some slight traces of incipient parallelism of structure due to traction It possesses no other structural peculiarity worth noting The latter fact, I may remark in passing, shows that when examining a single slice of a granitic rock under the microscope, with a view to determining whether it is of eruptive or metamorphic origin, mere negative evidence is not of much value

The Leo granite has several points worthy of consideration Nearly all the quartz in it is of polysynthetic structure, similar to the fish roe quartz of the Dalhousie gneissose granite , and this shows that the conclusion which I arrived at in respect of the latter—namely, that the fish roe grains do not indicate a clastic origin [1]—was sound

Another point to be noted is that liquid cavities with movable bubbles are not very abundant in the Leo granite Liquid cavities may be abundant in some parts of a granite and not in others , their sparseness, or even absence in a single *slice*, therefore, is of little importance in determining the igneous or metamorphic origin of a rock [2]

Evidences of strain are seen in the Leo granite in the curvature of the twinning planes and the cracking of felspar crystals

The muscovite of this granite polarises in delicate colours, but with extreme brilliancy, precisely as it does in the gneissose granites , the dullness of the muscovite of the Durwás and Pangi specimens, under the polariscope, does not therefore indicate any structural or varietal difference dependent on their mode of origin Both the Leo and Darwás specimens are from dykes intrusive in schists

In No 3, garnets and schorl are drawn out into strings—an indication, I think, of traction

The biotite in such rocks as the Jángi granite (Nos 5—12) may be usefully compared with the dark mica in such rocks as the gneiss of Hattu (Nos 51—53) and of Barela (Nos 61 and 62) In the former, the basal cleavage of the mica is well developed, the folia are oriented in all directions, and the biotite embraces garnets or other minerals In the gneiss alluded to, on the other hand, the dark mica is in minute scales which do not exhibit any basal cleavage , moreover, when slices of the gneiss are revolved over the analyser, the mica either fails to exhibit dichroism at all, owing to all the leaves being axial sections, or extinction takes place simultaneously in the whole, or in the majority of the leaves , an indication in both cases that the scales of mica are all in the same plane,—a fact that points to a metamorphic or clastic rather than to an igneous origin

[1] Records, Vol XVI, p 130

[2] To prevent any misapprehension of my meaning I may add that though the abundance of liquid cavities with movable bubbles is very characteristic of a plutonic eruptive rock—see remarks *ante* on the Wangtu beryl—liquid cavities are also to be found in some metamorphic rocks, as will be shown in my next paper

"Stone enclosures," which contain endo-minerals, gas, and lacunæ with fixed bubbles in them (figs 11—13), are to be seen in the Jángi granite

These stone enclosures afford good evidence of the rock which contains them having been subjected to great heat and of having been reduced to a more or less fluid or plastic condition, and they are useful for comparison with similar bodies formed in the gneissose granite

In the granite from the dyke that bursts through stratified rock at Rárang, a parallelism in the arrangements of the biotite resembling incipient foliation is to a limited extent observable on a macroscopic inspection

In the Pángi granites liquid cavities are very numerous, and the bubbles are of large size relative to the area of the enclosures containing them This indicates that the rock was subjected to great heat and pressure, whilst the perfectly crystalline condition of these rocks shows that they were in a fused or fluid condition and cooled slowly

A little microcline is present in the Pangi granite (14) and it is abundant in the Wangtu granite (20, 21)

I now pass from granites proper to the gneissose granites, or what used to be called the granitoid gneisses of the Sutlej valley

In mineral composition these rocks do not materially differ from those of the granite group above alluded to Both classes contain quartz, orthoclase, plagioclase, microcline, biotite, muscovite, schorl, garnets, and magnetite

With the exception of beryl and kyanite in the neighbourhood of Wangtu, and epidote and chlorite in some of the Chor specimens, I have not found any other minerals in the samples examined

In the gneissose-granite of Chora stone cavities or crystals, containing endo-crystals and enclosures (figs 5—8) of the same class as those found in the granites proper (figures 9—13) were found In fig 11 (Jángi granite) the microlith is severed by a crack, apparently the result of shrinkage In fig 5 (gneissose granite) the microlith is cracked in two places and dislocation has resulted owing probably to a tremulous movement passing through the viscid matrix

The gneissose granite of the Chor mountain contains a good-sized prism of quartz, with pyramidal terminations caught up in a large piece of felspar This seems to indicate a more or less fluid stage in which the quartz prism had time to form free from any excessive pressure from the surrounding felspar

Stone cavities, similar to those found in the granites, which have deposited endo-crystals, or mineral matter, occur in the Chor rocks, and illustrations of these bodies are given at figs 1—4 and 21

These rocks also contain coloured liquid or stony enclosures with fixed bubbles, and microliths that have cracked, apparently from shrinkage on cooling

I think the rocks which I have classed, in the above pages, as gneissose granites, afford under the microscope the same kind of evidence, and as good evidence, of having passed through a stage of *aqueo-igneous* fusion as the undoubtedly intrusive granites

The further fact that they have been in motion has been established for the exactly similar rocks of the Dalhousie area, and I hope in a subsequent paper

to give further and very convincing proof of the eruptive character of the latter

If the Dalhousie rock is granite, I do not think this style and title can be denied to the rocks which I have classed in this paper as gneissose granites

I must not be understood, however, to deny that in the North-West Himalayas we have to deal not only with granite and gneissose granite, but also with true gneiss The rock found on flank and summit of Hattu looks like a very typical gneiss, and the examination of thin slices under the microscope supports the view that this is its true character

I now pass on to consider the outer band of gneiss at Dalhousie Viewed macroscopically, this is a streaky foliated rock of schistose aspect, to which no one from a superficial study of it in the field, or from the examination of hand specimens, would think of assigning an igneous or eruptive origin

The question to be determined is whether these appearances are delusive, and the foliation is a pseudo-foliation due to traction, and the squeezing of a viscid rock between beds of hard strata, or between the walls of a fault, or whether the rock is a true gneiss

In mineralogical character these rocks do not differ from the gneissose granite of Dalhousie Like the latter, the outer band is composed of quartz, orthoclase, microcline, plagioclase, biotite, muscovite, cryptocrystalline mica, magnetite, ferrite, garnet, and schorl

Liquid cavities with movable bubbles, on the whole, are about as numerous as in the gneissose granite

Felspar is present in abundance in the outer band, but on the whole quartz probably predominates over it in amount Monoclinic felspar largely predominates over triclinic felspar

As in the gneissose granites of Dalhousie, the Sutlej, and the Chor, muscovite microliths are so abundant in some of the felspars as to nearly overpower the felspathic element

Not only do crystals of schorl and garnet contain liquid cavities with movable bubbles, but even microliths enclose them The presence of such cavities in these minerals, and in microliths, shows that the rock must have passed through a fused or plastic stage during which super-heated water must have been intimately mixed with the mineral forming substances in a state of flux Fig 20 is a sketch of one of the microliths alluded to, and it is of precisely the same character as that represented at fig 11, by its side, taken from the Jángi granite

Conditions of strain are indicated by the twinning planes of plagioclase being bent out of the perpendicular, whilst another felspar (fig 16) has apparently been cracked and the resulting pieces pushed over like books on a shelf

A crumpled mica, fig 15, occurs in one of the slices, which will bear comparison with fig 4, Plate II, of my paper on the gneissose granites of Dalhousie (Records, Vol XVI, p 133), and doubtless the explanation given of the latter applies to this one also

Strings of a white substance resembling leucoxene, and of red ferrite, which have resulted from the decomposition of magnetite, ilmenite, or other iron-bearing minerals, are common in these slices, and at fig 14 I have given a sketch of a

train of magnetite or ilmenite fragments entangled in a stream of leucoxene, and I have given my reasons in the preceding pages for believing that the leucoxene was not derived from the decomposition of the magnetite or ilmenite *in situ*.

At fig. 18 a "stone cavity" which has deposited crystalline matter on cooling, taken from slice No. 6, is represented, which will bear comparison with similar bodies found in the Aden lavas, and represented at figs. 4, 5, and 6 of the plate which illustrates my paper on those rocks. (Records, Vol. XV, p. 159.)

At figs. 17 and 19 (the latter is enclosed in a schorl crystal), I have sketched cavities containing air or gas bubbles, which have contracted subsequent to the consolidation of the rock, and now imperfectly fill the cavities which doubtless they once fully occupied, when expanded under the influence of heat.

The facts stated above appear to me to prove that the rock under examination was subjected to great heat; that it passed through a stage of aqueo-igneous fusion, and that before its complete solidification it was subjected to great strain and pressure.

If the inferences I have drawn from the train of magnetite or ilmenite fragments in the train of leucoxene, and from the presence of a crumpled mica, are sound, it also follows that the rock, or portions of it, were in motion.

The mere fact that the rock, or a portion of it, was in motion does not, of course, prove its eruptive character. Great pressure, exerted on sedimentary or metamorphic rocks, may result in motion; as, for instance, the cases in which limestones under the influence of great pressure imitate eruptive rocks and become intrusive in others. But in the case of the Dalhousie "outer band" the whole rock has evidently been in a condition of igneo-aqueous fusion, and evidence of motion in such a rock acquires additional importance.

If we take all these facts into consideration, together with the further fact that in mineralogical composition the rock under consideration is identical with that of the neighbouring gneissose granite, which has been shown to be an eruptive rock, may we not fairly conclude that both rocks have the same origin, and that the structural difference between them, which is one of degree only, is due to the outer band having been intruded as a sheet between hard strata, or forced between the walls of a fault in a viscid or partially consolidated condition, and subjected to great pressure and squeezing at right angles to the direction of the flow? I think myself this is a reasonable inference to draw from the evidence.

It is clear, as shown in the preceding pages, that the "outer band" has passed through a stage of aqueo-igneous fusion. On the other hand, I do not think that great heat is required to explain the metamorphism of the schists in contact with the "outer band" along its northern boundary—the passage of moderately-heated water through slates seems to be all that is necessary to account for the production of micas of the class to which those in these schists belong.

In a recent tour, the results of which I hope to publish in a future paper, I found highly micaceous slates, that might be classed fairly as mica schists, intercalated between perfectly unaltered dark blue carbo-triassic limestones—a circumstance by no means puzzling when we know that certain micas—all the hydro-micas probably—can be produced through the agency of moderately heated water

On the whole, then, I think there are good grounds for assigning a different origin for the "outer band" and for the schistose rocks in contact with it

The conclusion at which I have arrived, on a consideration of all the facts of the case, is that the invasion of previously metamorphosed strata by gneissose granite, combined with the pseudo-foliation of the latter due to the pressure of hard strata on a partially cooled and imperfectly viscid rock, has imparted to the intruded rock the superficial appearance of being a member of the same metamorphic series as the schists and slates into which it has intruded

There is no inconsistency, I would point out in conclusion, in supposing that the rock which gives evidence of having passed through a stage of aqueo igneous fusion was partially cooled and semi viscid where actually intruded into the schists Observation in our own time shows that there are pauses and long intervals in volcanic action, and doubtless similar pauses took place in plutonic action during which the cooling and partial consolidation of igneous masses went on and the large porphyritic crystals found in many of them were formed The subsequent motion of a partially consolidated viscid rock and its intrusion as a sheet between hard strata, or between the walls of a fault, would, it seems to me, naturally produce a parallelism of structure, or pseudo-foliation, as long ago pointed out by Scrope and Naumann [1]

The "outer band" of Dalhousie seems, in some respects, to be analogous to granulite (leptynite), a foliated rock associated with gneiss and other crystalline rocks in Saxony, Bohemia, and Moravia, which is classed as eruptive by Naumann, M M Fouqué and Michel Levy, and other petrographers [2]

The mica of granulite appears to be at times disposed "in scaly seams entirely dividing the rock," a marked characteristic of the "outer band" of the Dalhousie gneissose granite

DESCRIPTION OF THE PLATE

Fig 1 —Stone cavity, or microlith, in the gneissose granite of the Chor, which has deposited crystals on cooling Taken from slices 59—64

Figs 2, 3, and 4 —Opacite, probably magnetite, deposited in cavities Chor gneissose granite Slices 59—64

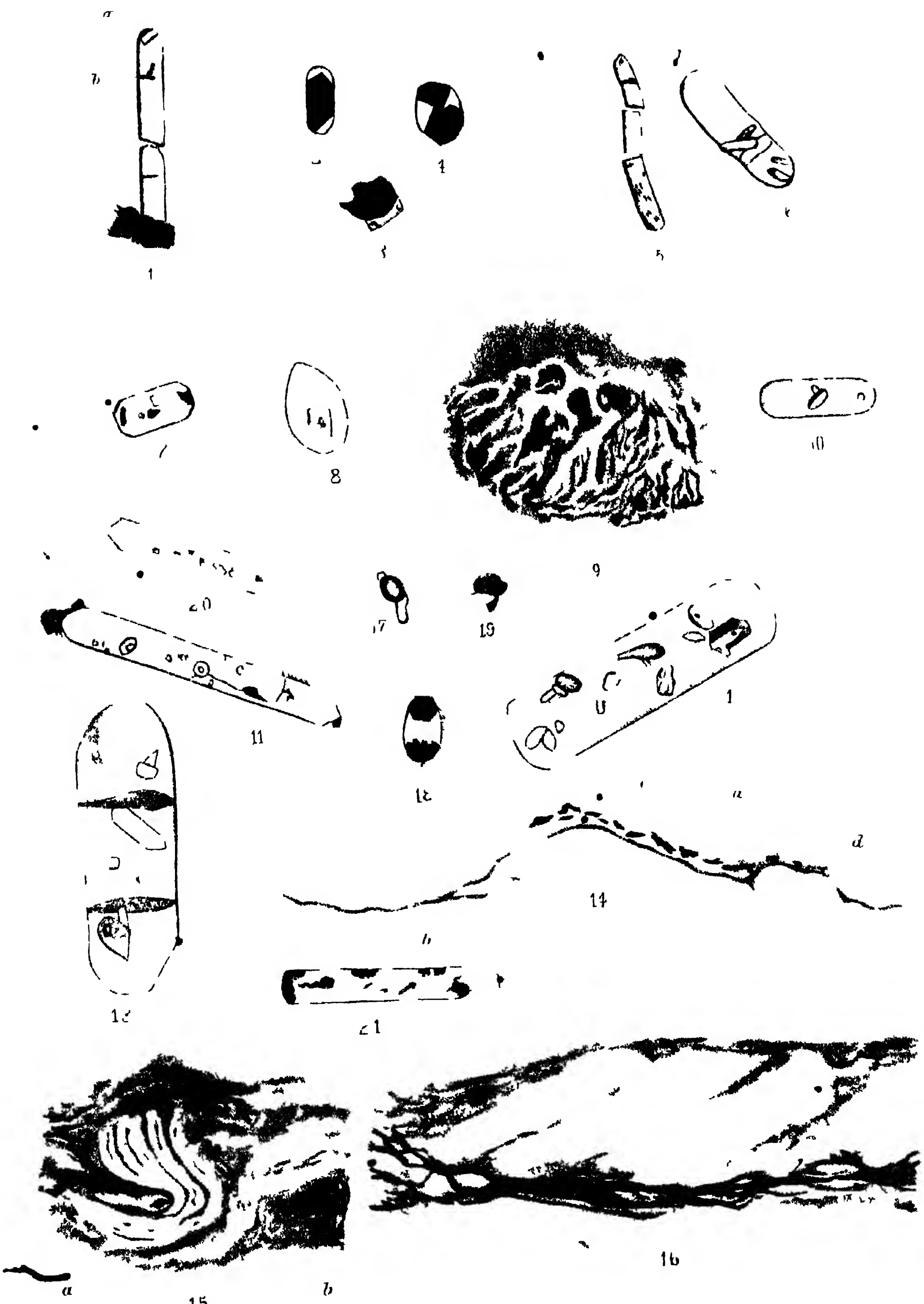
Figs 5, 6, 7, and 8 —Illustrations of stone enclosures, in which mineral bodies, enclosed in the gneissose granite of Chora, have either deposited minute crystals on cooling, or have, in the process of their own crystallisation, caught up previously formed microliths Slices 22—25

Fig 9 —Dendritic combinations of muscovite, microliths, gneissose granite, Wangtu Sutlej valley Slices 16—19

Figs 10, 11, 12, and 13 —Stone cavities containing crystals and internal cavities with contraction bubbles Granite, Jángi, Sutlej valley Slices Nos 5—12

[1] See Scrope, Q J G S, Vol XII, p 346 And his work on Volcanoes, pp 103, 144—202 Naumann "On the probable eruptive origin of several kinds of gneiss and gneiss-granite" Q. J. G S, Vol IV Translations and Notices of Geological Memoirs, p 1

[2] Geikie's Text Book of Geology, p 124 Cotta's Rocks classified and described, p 221 Mineralogie Micrographique, par M M Fouqué et Michael Lévy, p 174



I Schaumburg Lith^d

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Fig. 14.—Strings of red ferrite and a white substance resembling leucoxene in which fragments of magnetite or ilmenite are entangled. Outer band of gneissose granite, Dalhousie. Slice No. 1.

Fig. 15.—Crumpled mica. Outer band, Dalhousie. Slice No. 7.

Fig. 16.—A large felspar, cracked, split into pieces and pushed over as books on a shelf. Outer band. Slice No. 6.

Figs. 17 and 19.—Cavities containing air, or gas, that has contracted on cooling. Outer band, Dalhousie. Slices 6 and 12.

Fig. 18.—Stone cavity in which mineral matter has been deposited on cooling. Outer band, Dalhousie. Slice No. 6.

Fig. 20.—Microlith containing lacunæ with fixed bubbles. Outer band, Dalhousie. Slice No. 14.

Fig. 21.—Microlith that has deposited mineral matter on cooling. Gneissose granite, Choi. Slice No. 65.

Report on the Choi Coal Exploration,[1] *by* G. F. SCOTT, M.E. (With a map.)

In this report I purpose to take each place separately and treat of its coal prospects.

No. 1.
Choi, marked A on plan.

The coal here lies at the base of the hills; it had been worked previous to my arrival by means of headings driven in the hill-side and pits; there is hardly any coal left, nearly all having been worked.

A boring marked B on plan was put down to the depth of 80′ by Mr. Craythorne, but without success; it is evident that no regular seam of coal occurs, the quantity previously extracted lying in pockets. The strata are very contorted, and I question much, if coal were found, whether it would pay the cost of labour. Near the village, and along the Chablowala nuddy indications in the shape of black earth, and shale appear, but nothing substantial enough to guarantee a trial.

No. 2.
Between Choi and Mungi, marked C on plan.

Leaving Choi and proceeding eastwards, the outcrop is seen on the side of the main road, and also down the hill, further east, I put down a boring marked C on the plan. On reaching limestone, I stopped the boring and commenced sinking to the black shale met with at the depth of 32′ 4″. From here a heading was driven in the direction of the dip of the coal (which is almost perpendicular), but when it had been driven 8 yards the coaly shale thinned out; another heading was driven, but that also for the same reason was abandoned. No actual seam was met with, the black shale that was followed had small parti-

[1] The exploration described in this report was suggested and carried out by the Department of Public Works. In order that so searching a trial of the ground may not be lost sight of, the account of it is appropriately published in these Records. The locality is in the Chita range, ten miles south of Attock. A general description of the ground by Mr. Wynne was published in 1877, Records, Vol. X, p. 107. The pseudo coal measures are those near the base of the nummulitic series which have so often raised sanguine expectations of coal in the North-West Punjab.—H. B. M.

cles of bright coal in it, but this, as was observed above, gradually thinned out to nothing It is evident, therefore, that here and in the immediate neighbourhood where more indications are to be seen, there is not the slightest hope of any workable coal being found

Indications of coal crop out here and there along the foot of the hills, until the place marked D on plan is reached Here coal has been extracted by means of headings and pits, the latter are mostly full of water, so that the galleries underneath cannot be inspected, it is evident, however, from the headings that there is very little coal remaining

No 3
Boring at Mungi, marked D on plan

I put down a boring to the north of the previous workings, after a depth of 11′ 4″ limestone was reached, the boring was continued in this strata to the depth of 57′, the progress being slow, and there not being the slightest chance of striking coal, it was abandoned

There is nothing here to tempt another trial, the quantity of coal that may be left being very small

The outcrop continues almost in a straight line to the east To test the strata a boring was put down at the place marked E on plan It will be seen, on referring to the account of the boring, that up to date no seam has been struck, although a depth of 100 feet has been reached The boring is still proceeding, but I am afraid it will meet with no success

No 4
Boring east of Mungi, marked E on plan

Leaving the hills, I thought, in order to thoroughly test the locality, that a couple of deep borings should be put down in the plain where it is evident the strata lie more horizontally Accordingly, a boring was started at the place marked F on plan After meeting with great difficulties the strata have been bored through nearly to the depth of 200 feet, and by referring to the account, there does not seem much likelihood of meeting with success The boring is now in stiff blue clay, and probably limestone will be met underneath, should this occur it will be useless to proceed further

No 5
Boring near Haro, maked F on plan

A boring was commenced here intended to be as deep as the other, but at the depth of 55 feet an unexpected bed of sand and pebbles was encountered All the boring pipes being required near the Haro, it was abandoned Should, however, the present boring prove successful, it will be easy enough to start this one

No 6
Boring at Dheri Khot, marked G on plan

Traces of coal having been discovered between Choi and Bagh Nilab, I thought it would be as well to put down a trial pit On the 14th April it was commenced, and at the depth of 15 feet a heading was driven at an inclination of 1 in 3 Up to date, nothing substantial has been found, although black shale bands occur with particles of bright coal in them I do not think it probable that a seam lies here, but very likely a small quantity of coal, similar in nature to that at Choi, may be extracted

No 7
West of Choi, not marked on map

Between here and Bagh Nilab no indication of coal is found, at the latter place there are slight traces, but nothing sufficient to guarantee a trial

Summary

From what I have seen of this district, and from the several borings, the conclusion I have come to is, that the prospects of finding any sufficient quantity of workable coal either at Choi, Mungi, or the country lying to the west and east respectively, is very slight

The coal itself is of a poor quality and resembles black shale more than anything else, it seems to be a good gas producer, and that is all that can be said in its favour

The only chance of making this exploration a success has been tried,—that is, boring in the plain, had coal been struck, the seam would have lain at a more convenient angle, and there is no doubt but that there would have been a vast quantity of coal to work

It is very evident that no seam lies in the hills, and, with the exception of Choi and Mungi, no coal has been worked, although trials have been made in various localities, it is almost conclusive, therefore, that the coal lies in pockets, and to work this seems to me to be far too speculative

From J T O'CALLAGHAN Esq *Engineer-in-Chief, Punjab Northern State Railway, Northern Section, to the Director General of Railways,—No 1335, dated 17th May 1883*

I have the honour to forward herewith a report with plans on the search for coals in the Kala Chitta range of hills south of Attock carried out under the instructions conveyed in your No 622 C of 16th November 1882

Mr Scott's report confirms the opinion I had already given in my No 4074 of 22nd October 1880, to your address, and also the published opinion of the officers of the Geological Department

While Mr Scott was carrying out his exploration, I visited the district and went with him over most of the places where any indications of coaly matter appeared The Kala Chitta range of hills consists almost altogether of grey nummulitic limestone, the beds of which are much contorted and are traversed by many faults Near Choi the beds are tilted nearly vertical, and between two of the beds is a bed of brownish shale from 40 to 50 feet in thickness This shale bed is traceable for some miles in an easterly direction from Choi, and at intervals in it pockets of black coaly shale are found The pockets are lenticular in form and of no great extent in any direction, and when excavated have always died out within 40 or 50 feet of the surface of the ground The so-called coal when excavated has also proved to be of little value as a fuel It was of service in burning lime and keeping down the price of wood at a time when all prices had a tendency to undue inflation But the attempts to make it into patent fuel fit for locomotive purpose has been a complete failure, the heat given out being much inferior to that obtained from an equal quantity of wood fuel.

In my opinion, any hope of procuring coal in the Kala Chitta range may be abandoned now and for ever Had there been any appearance of a continuous seam of even the coaly shale found, deeper workings in it might have shown a better quality to exist below, but there is no continuity or regularity in the recurrence of these pockets, and the fine vertical section of the whole range of

hills which is made visible in the channel cut by the River Indus, shows that the great disturbance of the whole formation of these hills must preclude all hopes of horizontal beds of any kinds being found—see also opinion of Superintendent, Geological Survey, expressed in his letter No 255, dated 29th September 1880

What grounds Mr Johnson had for the statement made in his No 2845 of 12th August 1882, to the Secretary to Government, Punjab, paragraph 5, that "the pocket theory was found to be erroneous, the so called 'pockets' connected with each other and develope into seams, while the coal improves immensely in quality as the depth of the pits increased," I am at a loss to imagine In no case has any pocket been found to extend into a seam, and without exception they have worked out in every direction in which they have been tried, and when last at Choi Mr Johnson was unable to point out any continuous seam or to give any data on which his very sanguine report could have been founded I can only infer that Mr Johnson based his report on information received from a man named Craythorne, the practical miner referred to in paragraph 6 of his report This man was originally a soldier in the 44th Regiment, and was taken from the regiment to work in the Warora Mines in 1874 or 1875, which situation he left and wandered up-country in search of work His employment by the Executive Engineer was allowed, to assist in procuring fuel, and it was of course to his interest to make favourable reports in order that his employment might be continued He absconded from Choi a short time before Mr Scott's appointment

The boring marked F is still continued and sandstone under the blue clay is reported, but this is probably only one of the thin beds of sandstone everywhere seen in the recent deposits through which the Haro river has cut its way The ultimate results of this boring will be reported, but it does not seem necessary to delay this report for it

In conclusion, I beg to say that Mr Scott has taken much pains with the work on which he was employed, and I trust that he will be more successful in the Salt-range, where I understand the manager of the line is about to employ him He has been given the usual month's notice that his services will not be required further at Choi, and the tools, &c, used by him will be stored at Pindi until required elsewhere

From J T O CALLAGHAN, Esq, *Engineer-in-Chief, Northern Section, Punjab Northern State Railway, to the Director General of Railways,—No 1851, dated 12th June 1883*

In continuation of my No 1335, dated 17th May 1883, I have now the honour to forward Mr G Scott's supplementary report on the bore-hole put down near the Haro river at the point marked F on the plan already forwarded

I omitted to mention that the bore-hole was put down in the bed of the river about 70 feet below the average surface of the ground, and therefore represents a hole of a depth of about 320 feet

The record shows that nothing but alluvial deposits have been passed through, and go further to confirm the views I have always expressed regarding this district

Supplement to report on the Chor Coal Exploration.

In this supplement, I purpose to give a further account of the deep boring near the River Haro, mentioned in No. 5 paragraph of my former report. On referring to that, it will be seen that the boring had nearly reached the depth of 200 feet, and my supposition was that a bed of limestone was close at hand. It was then thought that it would be advisable to discontinue the work, but after further discussion it was decided to go on, and see what the nature of the stone was.

Accordingly, after clearing the boring, it was re-started on the 19th May, and at the depth of 201′ 6″ sandstone was reached; the rock proved, however, to be only 4″ thick, and below, beds of loam, sand, and dark yellow clay were met. At a depth of 233′ 11″ sandstone with a total thickness of 8′ 3″ was bored through, and then again a bed composed of a mixture of loam and sand was found.

Finally, on the 7th June the boring was abandoned, the depth then reached being 2[illegible]′ 6″ and the strata sandstone.

From the above short account, and from a study of the boring sheet noting the various strata pierced, the conclusion arrived at is, that even at the depth of 250 feet the boring had not gone below the silt and sediment deposited by the river: how far this deposit extends is a matter of conjecture, but, in my opinion, it would be some time before it could be bored through, and then no advantage would accrue, as it is highly probable limestone would be the strata met with.

The boring itself was put down in a ravine close to the Haro, and only 8 feet above low-water level. The cliffs which border one side of the river are 70 feet high, so that it will be seen that at the termination the boring was really 320 feet below the actual surface.

To have continued would have been a mere waste of time and money, as I have not the slightest hesitation in saying that a further search would prove utterly useless.

In my opinion, everything has been done with a view of finding a profitable seam of coal; the borings and trial pits have been put down in the most advantageous places, but without the success I confidently expected from the surface indications.

Section of Boring on the Haro River.

Depths	Strata	Depths	Strata
21′ 0″	Soil and pebbles	194′ 5″	Loam and sand
37′ 0″	Yellow clay	201′ 6″	4″ sandstone
70′ 0″	2′0″ sandstone	204′ 9″	Loam and sandstone
83 6″	Yellow clay	211′ 2″	Loam and sand
94 10″	2′ 6″ sandstone	217′ 5″	Dark yellow clay
108′ 0″	Yellow clay	233′ 11″	Soft sandstone
115′ 0″	Running sand	242′ 0″	Loam and sand
121′ 4″	Yellow clay	249′ 3″	Sandstone
144′ 2″	Blue clay	252′ 6″	
184′ 9″	Dark blue clay		

NOTE.—If Mr. Scott's figures can be trusted, of which I regret to hear there is some doubt, the boring on the Haro would be of considerable geological interest, as proving that this great spread of alluvium, the principal area of which is known as the Peshawar valley, lies in a deep rock

basin It has indeed become a safe general inference, that areas of deposition are thereby areas of depression, still new facts in evidence are not superfluous The surface level at the boring is only about 25 feet above that of the Indus, twelve miles to the west, where it turns at a right angle into its gorge through the Chita range

The expectation to find the coal flat and abundant under the alluvium in a region of extreme contortion as exhibited in the surrounding hills, is a speculation that could only occur to the "practical man"—H B M

On the re-discovery of certain localities *for* fossils *in the* Siwalik *beds, by* R D OLDHAM, A R S M, *Geological Survey of India* (With a map)

Having recently had the good fortune to re discover the long lost fossil locality described by Sir Proby Cautley at the base of the section in the Siwalik hills, it has been considered desirable to put on record a detailed description of the locality

For this discovery I am mainly indebted to Mr A Smythies, Deputy Conservator of Forests, who, when deputed a short while ago to enquire into the question of the effect which the clearing of the forests from the slopes of the Siwaliks has had on the floods that annually enter and cross the Eastern Jumna Canal, made careful enquiries of the survivors of those who were employed on its construction as to the locality from which the fossils had been obtained, the result of his enquiries was that they had been discovered during the excavations carried on in connection with the works in the Kalawala Rao These, which are shown in the annexed sketch plan, consist of the principal bund, A, which was designed to throw the waters of the stream into a channel which does not enter the canal, and a small spur, B, higher up stream, intended to guide the current against the principal dam On visiting the spot we found at the head of both the principal dam and the spur a very peculiar rock, a conglomerate with a calcareous sandy matrix full of fragments of clay and decomposed slate with hardly a particle of harder rock, such might very properly be called a "clay conglomerate," but "clay marl" must be acknowledged to be a misleading name, still gravelly clays are sometimes improperly called marls, and the name might be applied by an engineer who did not profess to be a geologist Through this rock are scattered, though not abundantly, small fragments of bone, always broken, water-worn, and disjointed, and without exception converted into oxide of iron (hæmatite) As described by Sir Proby Cautley, reptilian teeth were not uncommon, besides these we found a mammalian molar imbedded in a portion of the ramus, a piece of the thigh bone of a small animal about the size of a sheep, a piece of a rib of some large animal, and portion of the carapace of a tortoise

As regards its position in the section, the bed is exposed in the Kalawala Rao on the southern side of the anticlinal fully 1,000 feet above the lowest beds seen, here there are two distinct beds, but in the valleys to the west three or more are occasionally seen. The same or similar beds are well seen in the Kotri and Kusumri Raos, but I was unable to detect them in the Badshai Rao (Timli pass), while to the eastwards I doubt not it would be found if searched for, as I have seen a very similar bed in the Dholkund Rao, but at the time expecting to find the fossils in a clay bed I did not search it

This has an important bearing on the discovery of similar fossils on the northern face of the Nahan hill;[1] it is of course possible that the lower beds of the Siwalik range are of the same age as those of which the Nahan hill is formed, but taking into consideration their very different mineralogical facies and the fact that they being situated at a greater distance from the Himalayas are far more exclusively composed of sand and pass up into coarse conglomerates, it can hardly be called probable, and it is far more likely that the Nahan fossils were either of an entirely different age or that they were obtained from an outlier of the middle Siwaliks, as has been suggested by Mr. Medlicott (Mem. Geol. Surv. India, III, 105), and again by Mr. Theobald (Rec. Geol. Surv. India, XIV, 71).

On some of the Mineral Resources *of the* Andaman Islands *in the neighbourhood of* Port Blair; *by* F. R. MALLET, *Deputy Superintendent, Geological Survey of India.*

Towards the end of last year specimens of various minerals, which had been discovered in the neighbourhood of Port Blair by Mr. M. V. Portman, Assistant Superintendent, were sent to the Geological Survey Office for examination. Amongst them were found ores of chromium, copper, iron, and sulphur. Later on Mr. Portman himself visited Calcutta, bringing with him further samples. Judging from these, and from the account given by Mr. Portman of the ores as found *in situ*, the indications seemed to be sufficiently promising to make an examination of the ground advisable. I was accordingly directed to proceed to Port Blair and carry out such investigation.

Geological character of the country near Port Blair.

Although it may be assumed with some degree of probability that the geological structure of the Andamans is of very much the same character throughout, the only portion of the islands concerning which we possess any certain knowledge, from direct observation, is that comparatively near Port Blair. Messrs. Kurz[2] and Ball[3] have shown that the strata are mainly sandstone and shale, which have been much altered in places through the intrusion of eruptive rocks.

From Mount Harriet, one of the culminating points of a ridge to the north of the station, and about 1,200 feet above the sea, a wide bird's eye view can be obtained, which gives a good general idea of the orography, and indeed of the geology too, of the surrounding country. The island for many miles to the north of the harbour and Port Mouat is traversed by a number of parallel ridges, running a little east of north, which, like the Mount Harriet ridge itself, are probably formed, in the main, of sandstone and shale, with rather a high dip in most places. The sandstone is generally fine-grained, of yellowish-white, grey, or greenish tints. Nests of lignite have been found in it here and there. Occasionally it includes subordinate layers of conglomerate, composed of small, well rolled, mostly quartzose pebbles. More or less calcareous beds are also found

[1] *Vide* Mem. Geol. Surv. India, III, pp. 15-16. Rec. Geol. Surv. India, XIV, 71, note.
[2] Report on the vegetation of the Andaman Islands, p. 2.
[3] J. A. S. B. 1870, Vol. XXXIX, Pt. 2, p. 231.

amongst the sandstones, but I am only aware of one band of pure limestone[1] Between some of the ridges, at least, there are level bottoms of alluvial land Although this part of the island would seem to be composed very largely of sedimentary strata, eruptive rocks are by no means absent, serpentine, &c, having been met with in several places The structure of the hills to the south of the harbour appears to be less regular, and this irregularity would seem to be due to the greater development of eruptive rocks there Of these the most important is serpentine, which occurs both in large masses and in dykes The north-east part of Rutland island is mainly formed of it, the rock being dark green and often spangled with small crystals of bronzite Seams of white (triclinic ?) felspar, a few inches thick, traverse it here and there, but are not common There are also occasional thin seams of cellular quartz, containing some earthy oxide of iron, or of manganese, in the cavities Small layers of brown opal have been met with in the same connection These seams occur between joints in the serpentine the jointing is often strongly marked, and, when highly developed in one direction only, gives the rock somewhat the appearance of bedding Serpentine is also largely developed at Bird's Nest Cape and to the north, at Homfray's Ghat, and other places Hornblendic, chloritic, and felspathic forms of rock are frequently found in association with it

On referring to the map of India one sees that the line of elevation constituting the Arakan Yoma is represented further south by the Alguada reef, Preparis and Coco islands, and the Andamans The orographical connection between the Arakán and Andaman ranges is accompanied by an equally close geological one The formations of the latter "are extremely similar in appearance to the Negrais rocks of the Arakán Yoma, and in all probability belong to the same group"[2] Serpentinous intrusions are also common in the rocks of both localities

In as far as any *a priori* opinion can be formed from the above geological connection as to the metallic wealth of the Andamans, such opinion must be of an unfavourable character, as no useful ores are known to occur in the Arakán Yoma "The only ores [in Burma] which need be noticed for practical purposes," says Mr Theobald, "are those of iron, tin, lead, copper, antimony, none of which, save iron, are known west of the Sittoung,"[3] and the localities noticed by the same writer, where iron has been worked, are to the east of the Irrawádi. The apparent barrenness of the Arakán hills, however, cannot be taken as conclusively proving that the Andamans are equally unproductive, although certainly tending to suggest that such may be the case

Hematite, pyrite, and chalcopyrite at Ráng-u Cháng

Along the sea coast at Ráng-u-Cháng, a place some miles south of Port Blair, are highly altered or eruptive rocks Here and there these are traversed by veins, the main constituent of which is hematite, but which include a considerable proportion of pyrite (iron pyrites) and chalcopyrite (copper pyrites) in much smaller quantity The veins constituted of these ores are very irregular and sometimes

[1] P 85

[2] Manual of the Geology of India, Pt 2, p 733

[3] *Supra*, Vol VI, p 91

branching, but short and strangulated, none that I saw being traceable for more than a few yards In one place I observed a mass of pure pyrite more than a foot thick and two feet long, but it could be seen that vein died out completely within a few feet Although, therefore, individual specimens of somewhat imposing dimensions can be obtained, I saw nothing leading me to suppose that the mineral could be profitably worked Nothing like a steady vein is to be seen, and it would be obviously hopeless to mine on the chance of meeting with scattered irregular nest-like veins like the above The same remarks apply to the copper pyrites The proportion is too small, and the cupriferous veins too irregular, to allow of profitable work, although an occasional lump of some size may be obtained

In the jungle, perhaps 50 yards from the beach and the above-mentioned veins, Mr Portman had excavated some tons of ore, from what seems to be a true lode running in a N—S direction At the main excavation the lode is several feet thick at least, but the entire breadth was not exposed at the time of my visit The ore, taken in bulk, is composed mainly of chloritic quartz and hematite (occurring chiefly as micaceous iron) The other constituents are iron- and copper-pyrites Although large lumps of good hematite can be obtained (one that I saw contained a couple of cubic feet of mineral free from admixture), the ore in bulk is worthless as an ore of iron, firstly on account of the large proportion of quartz, and secondly on account of the pyrites, which is still more fatal The quartz might be separated to a considerable extent by picking, but it would be impossible to free the ore from sulphur in this way To mine in hard rock, and then hand-pick such a sulphurous ore, would be manifestly impracticable, when high-class ore in inexhaustible quantity is to be had on the surface in so many parts of India The amount of iron pyrites is too small to allow of the ore being worked for sulphur, and the proportion of copper pyrites is quite insignificant, although here and there a lump of some size may be obtained, one piece that I secured containing a couple of pounds of solid ore

The above is the opinion that I formed on the spot, but I have, since my return to Calcutta, been able to check it by assays of the ore A quantity, weighing perhaps a couple of tons, and which may be taken as a fair sample of the whole, had been brought in to Port Blair, and at my request Mr Portman had about three-quarters of the amount broken up small The broken ore and dust were thoroughly mixed together, and a large bagful taken, which was reduced to powder in the laboratory here and mixed again On assay it yielded—

	Per cent.		Per cent
Copper	10	= Copper pyrites	30
Sulphur	10 74	= Iron pyrites[1]	20 13
Insoluble siliceous residue	37 60		

More than half a million tons of pyrites are now used per annum in England for the manufacture of sulphuric acid The average percentages of sulphur in the mineral imported from different countries are as follows —

	Per cent
Spanish and Portuguese	46 to 50
Westphalian	44 5

[1] After deducting the sulphur in the copper-pyrites

	Per cent
Belgian	44
Swedish	42
Italian	35 to 46
Irish	35
Cornish	28

Out of 550,000 tons imported about 1880, 500,000 were from Spain and Portugal [1] Cornish and Irish pyrites "are, as a rule, cupreous ores, but of very low value Their chief fault is the poor percentage of sulphur, whereby the cost of carriage and manipulation, &c, is, of course, very largely increased All payments for storing, carrying, breaking, burning the ore, and treatment of the burnt residue, are as large for weak as for rich qualities, and therefore far heavier, relatively" [2] With reference to the value of these ores, 65,916 tons were raised in the United Kingdom in 1872, valued at £39,470, or £0-11-11¾ a ton in 1882, 11,074 tons were raised in Ireland, valued at £5,743, or £0-10-4½ a ton It will be seen, then, that the poorest class of ore in the English market contains about three times as much sulphur as that of Ráng-u-Cháng, and although the ore derives its value in part from the small amount of copper it contains, which is extracted from the residue after the pyrites is burnt, still it only fetches 10 or 12 shillings a ton The Ráng-u-Cháng ore would be unsaleable at any price, as the proportion of sulphur is so low that the ore would not support combustion in the kilns The pyrites could not be concentrated by hand-picking, firstly, because it is too much scattered through the gangue, and secondly, because, being much more brittle than the quartz and hematite with which it is associated, it would be broken during the operation into a powder which would require subsequent washing for its separation Such 'smalls' do not fetch more than a third the price of pyrites in lumps At present there is no demand for pyrites in India, but were such to spring up, ore like that hitherto obtained in the Andamans could not possibly contend against that from Spain

It is well known that many pyritous lodes contain little or no good ore at the surface, but at a moderate depth are rich enough This, however, is due to the decomposition of the back of the lode, and the carrying down of the valuable constituents in solution as sulphates The Ráng-u-Cháng ore is perfectly fresh and unchanged close to the surface, and consequently there is no such reason to anticipate an improvement by sinking deeper The lode may improve below the surface, but there are no grounds for anticipating that it will The same may be said with reference to the longitudinal extension By excavating along the course of the lode it may be found richer in some parts than where it has been tried, but it is quite as likely that it may be found very much the same,[3] or even poorer I recommended that a cut should be made across the lode at the present excavation, so as to ascertain the entire width, but at the time labour could not be spared

[1] A Manual of the Alkali Trade, by John Lomas, p 3

[2] *Ibid.*, p 11

[3] Mr Portman had made a smaller excavation at some distance from the main one, and the ore was of the same character

The ore was also assayed for gold, and found to contain a minute trace only, with no silver

Pyritous vein at south Corbyn's cove

A little south of Corbyn's cove the road to Brookesabad crosses a vein, which, on the west side of the road, is five yards thick The rock is a ferruginous and chloritic quartz containing a little iron pyrites disseminated through it, and copper pyrites in still smaller amount Between the road and the sea the vein is less definitely marked, being represented by several irregular smaller veins One of these consists of quartz containing a fair proportion of copper pyrites[1] mixed with iron pyrites As the vein is two feet thick at one point, large blocks of ore can be obtained presenting rather an attractive appearance, but within a few feet the vein thins out to two or three inches, then thickens somewhat again, and a few feet further on dies out altogether Taking the main vein in bulk, the proportion of copper ore is very low, while as a source of sulphur the amount of pyrites is quite insignificant The pyritous quartz was assayed for gold (and silver) and found to contain none

The vein runs about S 20° W, and may possibly be a continuation of that at Ráng-u-Cháng If so, there is a considerable change in the character of the ore, that at Corbyn containing much less iron and more copper.

Clay ironstone nodules in shale

Some of the shales in and about Port Blair contain lenticular nodules of clay-ironstone of varying size up to 6 or 8 inches diameter They are not sufficiently plentiful, however, to be of any practical use

Magnetic iron sand

A specimen of black iron-sand from Havelock Island, which was sent to me by Colonel Cadell, the Chief Commissioner, was found to consist of magnetite

Chromite at Chakargaon

In Volume XVI, p 204, an extract is given from an official letter of Mr Portman's to the Chief Commissioner, describing the position in which a large block of chromite, and some smaller pieces, were found at the village of Chakargaon Mr Portman pointed out the locality to me, of which I subsequently made a close examination The village is situated at the foot of an irregular line of rounded hill which runs south-westwards from Mount Haughton, and which is formed of sandstone and shale with some subordinate calcareous strata The large block of chromite was found a little south of the village by the side of a small water-course It was a loose piece resting on, and partly embedded in, a talus composed of sandstone fragments The other lumps were found close by in a similar position Just south of the block is a somewhat larger watercourse, in which an almost continuous section of the rocks is exposed from the foot of the hill to near the top They are exclusively shale and sandstone, with a high dip to the south-east, and no fragments of serpentine (or of chromite) are to be found in the stream The hill is, I believe, beyond doubt composed entirely of shale and sandstone from the position in which the chromite was found to the summit As there is every reason to suppose that the chromite here, as in so many other parts of the world, occurs in connection with serpentine, it is, I think, certain that

[1] About 30 per cent, or 10 per cent. of copper

the blocks did not come from the hill-side above. From the site of the block there is a gentle slope downwards for about 20 yards, at the foot of which an alluvial flat begins, beneath which there may be a mass of chromiferous serpentine which formerly extended over the position of the block, but which has been cut away by denudation. At the very foot of the hill, indeed, there is a mass, some feet across, of a serpentinous rock mixed with calcite.[1] Similar rock can be traced at intervals along the foot of the hill, both to the south west and the north-east, but although I followed it for about a mile, not a single piece of chromite was to be seen in connection with it.[2] I had a trench excavated across the outcrop of this rock at Chakargaon, but no chromite had been met with at the time I left Port Blair. I think the continuation of this trench would be the best way to carry on the work, although I cannot say that I feel very sanguine of success. That there is a deposit of chromite concealed somewhere not far from the spot where the blocks were found, is clear, but that such deposit is a large or persistent one is more doubtful. If a strong vein, or number of lenticular masses extending along a certain line, existed of such ore, which is not liable to decomposition, the mineral would most probably betray itself by fragments along the outcrop. Yet none such have been found except in the one spot.

Chromite at Rutland Island.

The occurrence of the mineral at Chakargaon being an indication that the Andamanese serpentine is more or less chromiferous, it seemed to me that the localities where serpentine was known to occur elsewhere should be examined. With this view I went with Mr. Portman in the G. S. *Celerity* to Rutland Island, the north-eastern part of which is almost wholly composed of the rock in question.[3] I ascended four different streams, but in none of them was a single pebble of chromite to be found. Mr. Dawson, however, in washing for platinum in three of these streams,[4] obtained more or less fine black sand, which on examination proved to be the mineral we were in search of. On the sea beach, at the mouth of one of the streams, similar sand, which had been brought down by the current and then beaten back by the waves, was met with in layers more than an inch thick. When the sand from all these localities is examined under the microscope, it is seen that, in considerable proportion, the grains are well-formed octahedral crystals, with the edges scarcely at all rounded by attrition. By pounding, sifting, and elutriating the massive chromite of Chakargaon, a sand can be artificially produced which, to the naked eye, resembles that of Rutland Island, except that it is less lustrous in appearance. Under the microscope, however, no crystals can be detected, the sand being made up of irregular broken fragments. It is the crystalline facets of the Rutland Island sand which gives it its lustre.

Taking, then, into account that not a single fragment of massive chromite was found, and that the sand could not, apparently, have been produced from the comminution of such, I am strongly inclined to believe that the mineral occurs

[1] The "diorite and porphyritic trap," mentioned at p. 204, Vol. XVI, do not exist.

[2] The hill has been completely cleared of jungle, so that the outcrop is not concealed by vegetation.

[3] P. 80.

[4] P. 85.

disseminated through the serpentine in minute crystals, and therefore in a form of no practical value I should mention that one of the streams ascended was not more than half a mile long altogether, the place where the sand was obtained being about midway in its course Even, then, putting the crystalline character of the sand out of count, it is difficult to believe that the substance in mass could be so completely and finely comminuted during so short a journey

Search for chromite elsewhere

I also examined the serpentine at Bird's Nest Cape, at Homfray's Ghát, in the hills south of Corbyn and Protheroepur, and in more than one locality north of the harbour, but found no massive chromite at any of those localities I cannot help suspecting, therefore, that the mineral is not very plentiful in that part of the Andamans The contrast between the streams in Rutland Island and those in the Hánlé Valley in Ladák,[1] where also serpentine is largely developed, is very marked In the latter, lumps of chromite, often many pounds in weight, are scattered about in plenty

Search for platinum

In the not very numerous cases in which platinum has been traced to its parent rock in other parts of the world, it appears to have been found, in most instances, either in auriferous quartz veins traversing crystalline rocks, or (accompanied frequently by chromite) in serpentine Search was consequently made for it at Rutland Island Mr Dawson, the gunner of the *Celerity*, who had had many years' experience in Australian gold-washing, washed in three different streams, but not a single particle of the metal was found

Limestone

About 300 yards north-east of Chota Protheroepur a band of massive cream-coloured and greenish-white limestone, containing veins of calcspar, outcrops at the foot of the hill The strata dip at a high angle, and the band is several yards thick, but does not show above the alluvium for more than 30 yards or so along the strike The same band outcrops again, however, with a thickness of 10 or 12 yards, in a hillock about half a mile N 35° E of the village Although it is only exposed at the south-west end of the hillock, it probably extends the whole length, for say 100 yards, beneath the surface soil, if so, there is a large supply above the level of the alluvium, and consequently available by open quarry On the north-west side of the village of South Corbyn the rock outcrops a third time, forming a small hillock The band seems to be about 8 or 10 yards thick, dipping at 70° part of the limestone there is reddish

An analysis of the rock from the first-named outcrop gave—

Carbonate of lime	96 45
„ „ magnesia (by diff)	09
„ „ iron	1 16
Insoluble residue (mostly sand)	2 30
	100 00

As there appears to be a considerable (although not unlimited) supply available from free-draining quarries, and a much larger quantity by going beneath

[1] Memoirs, G S I, Vol V, p 166.

the level of the alluvium, it is worth consideration whether this limestone could not be profitably exported to Calcutta[1] The most distant outcrop is less than a mile from the sea at Corbyn, where the stone could be loaded into boats and taken round to the harbour Lime has for some years past been imported into Calcutta from Katni, in the Jabalpur district, if it pays to transport it more than seven hundred miles by railway, it would certainly seem that it ought to pay to transport the stone about the same distance by the much cheaper sea carriage[2] The Andaman stone is fully equal in purity to the best of that from Katni, an analysis of the latter yielding—

Carbonate of lime	94 65
„ „ magnesia (by diff)	2 98
„ „ iron	58
Insoluble residue	1 79
	100 00[3]

Besides its use for lime, the Andaman stone would make a good cream-coloured marble It could be quarried in large blocks, or in slabs, several feet in length and breadth A reddish marble could also be obtained

While on the subject of lime, I may mention that there is an inexhaustible supply of volcanic ash, or puzzolana, at Barren Island, similar to that obtained from some of the extinct volcanoes of Central France, and so largely used there as an ingredient of hydraulic mortar

Serpentine

Mr Ball has already alluded to the serpentine at Homfray's Ghát, from an economic point of view[4] The stone is mostly weathered and shattery on the surface, and to obtain it in a perfectly sound condition it would be necessary to quarry some distance into the hill-side Scattered over the hill, however, especially near the top, are numerous large blocks of stone which have resisted disintegration to a great extent, and some of which are fairly sound, although, being more or less fissured, it is doubtful if slabs of large size could be cut from them But if serpentine should be locally required in small quantity, for the supply of which it would not pay to open a regular quarry, these blocks would be worth attention

Serpentine is known to exist in many other places, but, taking quality into account, there is none, perhaps, more favourably situated than that just mentioned

Jasper

In the midst of some reclaimed land at Aberdeen Mr Portman discovered a large mass of variegated red jasper, which has doubtless been exposed through the denudation of the softer rocks around it It would make a handsome ornamental stone if polished, but in cutting large slabs there would be some risk of meeting with drusy cavities which occur here and there through the rock.

[1] The lime now used at Port Blair is made from coral, but I was informed by Colonel Protheroe, the Deputy Superintendent, that it is of rather inferior quality, as the salt cannot be thoroughly washed out of the raw material, and subsequently effloresces out of the mortar

[2] In this connection it may be noted that 100 maunds of (pure) limestone yields 56 maunds of quicklime and 73 of slaked lime

[3] Vol. XVI, p 112

[4] J A S B, 1870, Vol XXXIX, Pt. 2, p. 237

The Intertrappean beds *in the* Deccan *and the* Laramie group *in* Western North America, *by* M NEUMAYR (*Translated from the Neues Jahrbuch fur Mineralogic, etc, 1884, Vol I*)

White's recent work on the fossil land and fresh-water shells of North America[1] gives for the first time a good account of these forms, the literature concerning which was formerly so scattered as only to be studied with much trouble, many relations are shown to extra American forms, amongst which I propose to consider at least one, since the subject not only possesses interest itself, but also serves the purpose of correcting a former erroneous opinion of mine

Many years ago Hislop[2] described several shells occurring in some fresh-water beds at Nagpur interstratified with the enormous basalt masses of the Indian peninsular, known as the Deccan trap The most generally received opinion is that these beds belong to a period on the boundary between the cretaceous and tertiary epochs, since, however, a *Unio* resembling our European *U flabellatus* was found, and the genus *Acella*, which at that time was only known in the pliocene of Slavonia and living in North America, is represented, I ventured to point out the possibility that the intertrappean beds might belong to the later tertiaries[3] A comparison between the fossils of these intertrappean beds and those of the Laramie beds of North America which lie between the chalk and eocene shows very close relations between the two, and I can no longer hold my former opinion in the face of these results

Though the number of the genera of the fresh-water shells of Nagpur is far from small, the greater part is so indifferent, or the preservation and description so insufficient, as to render only the smaller half of use for judging of the character of the fauna, amongst these the most important is *Physa prinsepi*, Sow, which reminds one of the large kinds of Physa of the Paris and London eocene, but which is also closely related to the Laramie fossils of America, as *Ph copei*, Wh, and *Ph disjuncta*, Wh The above-mentioned exceedingly attenuated *Limneæ* which have been grouped together in the subgenus *Acella*, and which are represented in the Laramie beds by *A haldemani*, Wh, form another striking occurrence, *Paludina virapai*, Hisl, closely resembles *Hydrobia anthonyi*, M and H Among the snails a few other similar cases occur, the forms, however (*Paludina acicularis—Hydrobia recta, Paludina conoidea—Hydrobia subconica*), are so little distinctive that I place small value on them The Valvata are the only characteristic gasteropod types of Nagpur not represented in the Laramie beds of North America

Among the mussels the Unios are foremost, they have much in common in general appearance, but *U carteri*, Hisl, a form of the type of the European *U flabellatus*, is the only one that shows any close connection with *U gonionotus*, Wh, and *U gonioumbonatus*, Wh, of North America Finally, *Corbicula ingens*, Hisl, is remarkably similar to *Corbicula cleburni*, White

[1] White, a review of non marine fossil mollusca of N America Extract from the annual report of the Director of the U S Geological Survey, 1881 82

[2] On the tertiary deposits associated with trap rock in the East Indies Quart Journ Geol Soc, 1860, page 154.

[3] Neumayr und Paul, Congerien und Paludinen schichten Westslavoniens Abhandlungen der geolog Reichsanstalt, Vol VII, 1875

Whether in the one or the other case there may be actual identity, or whether it is, as I think more probable, a case of near related vicarious species, I cannot decide On the whole the following forms may be correlated —

Nagpur	Laramie
Physa prinsepi	*Ph copei*
" " var *elongata*	*Ph disjuncta*
Acella attenuata	*Ac haldemani*
Paludina virapai	*Hydrobia anthonyi*
Unio carteri	*Unio gomonotus* / " *gomoumbonatus.*
Corbicula ingens	*Corb cleburni*

These facts justify the conclusion that the intertrappean beds of India are the most nearly related of any fresh-water beds yet known to the Laramie beds of North America—a result which agrees well with the most generally received opinions with regard to the age of both Whether both belong to cretaceous or tertiary formations the fresh-water shells give no decided means of judging, many forms—for example, the large *Physa*, *Melania wyomingensis*, and others of the Laramie beds—are nearly related to tertiary types, but side by side with this are found surprising relations to European cretaceous forms I will not, however, enter here more particularly upon this point, since Dr Tausch is at present engaged in my institute upon studies which will yield evidence in this direction

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April 1st, 1884

Government of India Central Printing Office —No 37 S G S —24-4-84 —720

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3] 1884 [August

On the microscopic structure *of some* Arválı rocks, *by* COLONEL C A McMAHON, F G S (With a plate)

Dosi

Dosı, an ısolated hıll wıthın the Arválı area,[1] between Narnoul and Khetrı, rises more than 1,000 feet above the neighbouring plain,[2] and forms a striking object for many miles around Its steep sloping sides and cup-like top give the hıll an appearance not altogether unlike a volcano

It is curious how prone some people are to think that every cup-like depression observed on the crest or spur of a mountain is an old crater I have several times been asked whether Kajiár, a beautiful glade in the forest within 9 miles of Dalhousie, is not an old volcano, although there is not a modern volcanic rock in the whole district, and the upper silurian, or pre-carboniferous, altered basalts are many miles distant

In the case of Kajiár and Dosi, the formation of these cup-like depressions seems to be in great part due to what one may call the eccentricities of sub-aërial decay Crystalline rocks, apparently composed of exactly the same materials, and struck out of the same mould, as it were, vary very capriciously within a few yards in their power of resisting the elements of decay

Many curious instances of this are to be seen at Dosi, where deep grooves, several feet in depth and in diameter, have been carved out of the sides and faces of huge granitic blocks by sand-laden wind aided by the selective agency of natural decay. When they are of small size, they remind one very much of the pot-holes and furrows, formed by the action of water, so often to be seen carved on boulders in the beds of Himalayan rivers, but such agency is of course not to be thought of in the case of rocks on the top of an isolated hill, like Dosi, situated in a sub-desert tract, where the rainfall is very small. Moreover, in some of those carved horizontally out of the face of a rock the deepest portion is at times connected with the top and not with the bottom of the groove

[1] Described by Mr C A Hacket in his paper *On the Geology of the Arváli region, Central and Eastern*, Records XIV, 279

[2] The point I reached, which was not, I think, the highest, was 2,110 feet above the sea by my Aneroid barometer and 1,110 feet above the village at its foot where the ascent commenced

Nor is it necessary to call in the agency of water to explain the formation of these grooves In the Dosi region, fierce westerly winds, heavily laden with sand from the neighbouring plains, prevail for many months during the year Gullies amongst the rocks bring heavy gusts of wind to a focus, as it were, and make them do the work of sand-blast boring machines

In the neighbourhood of Dosi and Narnoul, the hills, some of them consisting largely of actinolite schists, are traversed in all directions, but generally more or less across the strike of the strata, by dykes of white granite It is a very coarse-grained rock consisting principally of felspar and quartz with occasional lumps of schorl 2 or 3 inches in diameter Mica (white muscovite) is rather rare, but here and there it is well developed Some of the quartz grains are larger than oranges, and I measured one 7 inches across

Dosi itself is composed wholly of the rock, about to be described, which is marked gneiss on the map which accompanies Mr Hacket's paper on the geology of the Arváli region It is a fine-grained rock of pale pinkish buff colour composed of quartz, felspar, black mica and black hornblende, the latter predominating over the mica

A general parallelism in the arrangement of the hornblende and mica, and which coincides with the strike of the sedimentary strata in the neighbourhood, is observable in the field on a careful inspection Sometimes the rock weathers out into smooth massive blocks, like true granite, at others it becomes slightly furrowed on the surface, the furrows striking north-east 15° east

M —Nos 1, 2, 3, and 4 The following is a description of the structure of the Dosi rock as seen in thin slices under the microscope These slices contain quartz, orthoclase, plagioclase, microcline, black mica, hornblende, micro-garnets, and a little magnetite

The quartz is about as abundant as the felspar Triclinic felspar is very plentiful, and there are numerous pieces of microcline, but none of them are of large size Prismatic cleavage is frequently well exhibited in the orthoclase

The quartz contains multitudes of liquid enclosures with fixed and movable bubbles, and in many, crystals have been deposited on the cooling of the liquid, as shown at figs 23, 30, 31, 32, and 34 The enclosure depicted at fig 23 contains a crystal and two bubbles The right-hand one, which is a gas bubble, certainly moves, though the movement is confined to contracted limits, the left-hand one, which appears to be an ordinary vacuum bubble, is either fixed, or its vibrations are so circumscribed that I could not feel sure that it really moved

Figs 30, 31, 32, and 34 of the plate which accompanies this paper may be usefully compared with figs 79, 80, 81, and 83, Plate XVIII, Q J G S, Vol XIV, which accompanies Dr Sorby's paper on the microscopical structure of crystals, and which depict similar liquid cavities found in nepheline blocks ejected from Vesuvius

The quartz of the Dosi rock contains numerous liquid cavities with gas bubbles One of the latter type is sketched at fig 33

At fig 35 I have depicted a liquid cavity contained within a negative quartz crystal, that is to say, the *cavity* has assumed the shape of a small quartz crystal with bi-pyramidal terminations There is no doubt about its being a liquid

cavity as the bubble is a movable one Cavities of this character seem to prove that the quartz was in a state of flux, as does also the presence of some perfectly hexagonal microlithic plates of mica enclosed in it here and there

Fig 35 of the plate attached to this paper may be compared with fig 114 of Plate XIX of Dr Sorby's paper just referred to The latter represents a liquid cavity, in the shape of a quartz crystal, containing a bubble and a deposited crystal The cavity was observed in the quartz of the granite from the Ding Dong mine near Penzance

Some of the bubbles in the liquid cavities observed in the Dosi rock appear to be ordinary vacuum bubbles, but many of them are gas The latter are quite round, but occupy a much larger area relative to the size of the cavity than the vacuum bubbles and affect light differently

In one enclosure, which I have not sketched, the crystal deposited within it is distinctly cubical and is probably sodium chloride those depicted in figs 30 31, and 32 are corroded like the one represented at fig 55, Plate XVII of Dr Sorby's paper already quoted

For the sake of comparison, I have studied some thin slices of typical rocks from Scotland prepared by Mr J M Bryson, of 60, Princes Street, Edinburgh, from specimens selected for him by Professor Giekie In them I find very similar objects to those described in the preceding pages Fig 24 is a liquid cavity containing a bubble and a crystal probably of sodium chloride, and fig 25 represents a gas inclusion, both taken from granite invading metamorphosed lower silurian rocks

In the Aberdeen granite, microliths, many of them apparently of quartz with bi-pyramidal terminations rounded or more or less modified, are very abundant in the quartz and felspar They contain shrinkage cracks and cavities and lacunæ with fixed and movable bubbles Figs 26, 27, 28, and 29 are taken from the Aberdeen slice Exactly similar bodies are common in the gneissose granites of the North-West Himalayas, and figs 26—29 may be usefully compared with figs 11 and 20 of the plate annexed to my paper in the last number

Fig 16 is the sketch of a stone enclosure found in the Dosi rock under description It is a round mass of coloured crystalline matter enclosed in limpid colourless quartz It contains four fixed bubbles of different sizes

Such cases as those illustrated by figs 16 and 35, taken in connection with the other illustrations, prove, I think conclusively, that the Dosi rock passed through a stage of aqueo-igneous fusion

Under the microscope, no difference in structure can be detected between the Dosi rock and the intrusive granite of Aberdeen with which it has been compared, but nevertheless I hesitate to class the former as a true granite The evidence shows at all events that either the Dosi rock is a true syenitic granite, or the metamorphism of a crystalline rock of the Dosi type is the result of aqueo-igneous agencies sufficiently powerful to flux the materials.

Delhi quartzites

Nos 5, 6, and 7 are from the rocky ridge to the north of Delhi, where our army took up its position during the memorable siege of 1857 These quartzites

range in colour from a light to a dark grey With the aid of a pocket lens, very minute specks of dark mica, and of iron, may be discerned disseminated through them, and owing to the abundance of the iron, long tear drops may very frequently be observed coursing down the faces of weathered blocks These rusty-looking streaks are formed by rain trickling down the sides of blocks and causing the peroxidation of the iron contained in the rock in the form of magnetite

M —These slices are seen under the microscope to contain numerous flakes of a colourless mica, minute garnets, prisms of schorl and micro sphenes There are also rounded microliths of dark mica Magnetite and much red and yellow ferrite are also present Some of the garnets are much corroded at the edges, and altered into ferrite and into a greenish fibrous dichroic material

The Delhi quartzite is an extremely interesting rock, as it contains evidence of having been subjected to great heat, sufficient to have allowed considerable freedom of motion amongst its constituent molecules Microliths contain what are to all appearance shrinkage cavities, as for instance figs 17, 18, and 21, very minute indeed, but still comparable with such illustrations taken from the Aberdeen granite as figs 27 and 28 The evidence afforded by these microliths, however, is by no means conclusive, as in the case of a quartzite one might suppose that these bodies appertain to the quartz grains of the original sandstone, and that the latter were derived from some ancient granite and retained within them the stamp of their eruptive origin But this cause of doubt is I think, removed by the cumulative evidence afforded by the other objects about to be described, and by the fact that all trace of the quartz grains of the original sandstone from which the Delhi quartzite has been derived has been obliterated

That the molecules of matter contained in the Delhi quartzite enjoyed considerable freedom of action is, I think, shown by such objects as those depicted at figs 11, 12, 13, 17, 20, 21, and 22

Figs 12 and 17 illustrate the case of opacite drawn towards and attached to microliths, which in the former case had certainly formed before the opacite Figs 20 and 21 represent microliths, in the former case quartz and in the latter mica, which have caught up micro crystals and opacite, and have retained them in their embrace on consolidation Similar bodies have also formed on the outside of the microlith depicted at fig 20, and the latter also contains a fixed bubble These objects very closely simulate the appearance of true stone cavities

Fig 13 represents an opaque crystal embraced by a flake of mica, fig 22 is an air, or gas, bubble surrounded by a ring of coloured mineral matter, whilst fig 11 is an air bubble partially clasped by minerals.

Fig 19 is the representation of a liquid cavity of imperfect hexagonal shape, the imperfection of the shape being probably due to the fact that the slice was not taken at right angles to the axis of the cavity I observed many liquid lacunæ of hexagonal shape in the quartz of slice No 6, with movable bubbles in them, and their presence seems to show that the quartz prior to final consolidation was in a fused or plastic condition

The cavity depicted at fig 19 contains two liquids, and an inner bubble that is in a state of violent activity, dashing about from side to side in the wildest

possible way. The smaller drop of liquid is apparently carbon dioxide, as the movable bubble temporarily disappeared on the application of very low heat

Ordinary fluid cavities with movable bubbles are extremely numerous throughout the quartzite

Tushám[1]

The village of Tushám is situated about 14 miles to the north-west of the town of Bhewáni, and about 85 miles west 11° north of Delhi

The village nestles on the eastern side of a low rocky ridge under 2 miles in length, which, towards its centre, rises to a height of 630 feet above the adjoining plain and culminates in a conical hill that forms a striking land mark for 20 miles around

The summit is difficult of access and is crowned by the ruins of a small fort, the building of which is popularly attributed to Raja Pithora

Small caverns in the rocky side of the hill, partially filled with water, are considered peculiarly holy pools, and are visited by a number of pilgrims, three "melas," or religious fairs, being held during the year

There are three rock inscriptions[2] at Tusham which, in General Cunningham's[3] opinion, belong to the time of the later Indo-Scythian Princes, and were cut between A D 57—69

The eastern flank of Tushám is composed of chiastolite schists, the dip of which is either vertical, or extremely high west 11° north to west-north-west, and the strike of which ranges from north 5° east, on the north-east extremity, to north-north-east at the south-east end of the outcrop To the west of these schists there follow pale grey argillaceous beds containing numerous small fragments of quartz, and traversed in all directions by red ferruginous lines

The centre and western side of the ridge is composed of felsites, or micro-quartz porphyries, described further on I was for some time doubtful whether these rocks were of igneous or of metamorphic origin, and thought they might represent beds similar to the argillaceous gritty rocks, alluded to in the last paragraph, in a more advanced stage of metamorphism, but now that I have examined thin slices of them under the microscope, I am satisfied that they are of igneous origin

I may note in passing that whilst the specific gravity of the argillaceous rock referred to is as high as 2 95, that of the felsites ranges from 2 63 to 2 77 and averages 2 71

Two dykes of quartz porphyry traverse the ridge, one on the eastern and the other on the north-western side The latter cuts across the ridge from the north-west to the north-east side The dykes are not parallel to each other, but their strike diverges at an angle of 46° The eastern dyke cuts obliquely across the bedded rocks at a low angle, it throws out a tongue into the adjoining rocks, at

[1] Tushám and the neighbouring hills described in the following pages are coloured as gneiss on the map which accompanies Mr Hacket's paper on the Arváli region, Central and Eastern Records, XIV, 279

[2] One of these is said, in the Archæological Report, to be cut on basalt.

[3] Report, Archæological Survey of India, Vol V, p 136

right angles to the direction of the dyke, and in another place, near the edge of the dyke, encloses a mass of them The quartz porphyry is clearly an intrusive rock

Granite crops out on the southern, south-western, and western flanks of the hill, whilst the northern portion of the ridge is traversed by granite veins ranging from a few inches to a few feet in thickness Some of them cut across the strike of the other rocks About a mile or so to the east of Tushám there is a small isolated hill of granitoid quartz porphyry

I now pass on to describe briefly the characteristics of some of the Tushám specimens as seen in thin slices under the microscope

Chiastolite schist

No 8 —Chiastolite schist from the south-east side of the Tushám ridge A reddish-brown rock, with numerous minute plates of mica glistening on the surface, and in which radiating crystals of chiastolite are imbedded

M —The ground mass contains numerous shapeless grains of magnetite, and it is much stained with red and yellow ferrite It is seen to be composed of quartz in grains, but the structure of the rock is very much obscured by the presence of a considerable quantity of iron Most of it is in the form of hæmatite, rounded or imperfect hexagonal disks of the blood-red mineral being abundant

The chiastolite crystals present nothing unusual in their appearance

I failed to find gas or liquid cavities in the quartz

Quartz porphyry

Nos 9-14 Sp G 2 67 —In a ground mass which appears compact to the unaided eye, numerous and rather large crystals of quartz and felspar are porphyritically imbedded Some of the felspar crystals are an inch in length With the aid of a lens, the ground mass appears to be a mottled mixture of felspar and dark mica The pyramidal ends of some of the quartz crystals, nearly perfect in form, stand sharply out from the fractured surface of one of the hand specimens

M —The ground mass under the microscope is seen to vary in structure from micro-felsitic to micro-granitic There appears to be a tendency in the material of the ground mass to arrange itself in concentric and radiating structures, nothing definite has resulted, however, from this tendency but shadowy phantoms that suggest rather than possess distinct forms

There are two imperfectly shaped pieces of hornblende ranging from reddish-brown to greenish-brown colour in transmitted light Dark mica is very abundant partly in congeries of small flakes and partly in stalk-like or quasi-prismatic forms The latter look, at first sight, very much like microliths of hornblende, but they are of exactly the same colour as the mica, and I can discover no reason for distinguishing them from that mineral They are so thin that between crossed nicols their optical properties are swamped in those of the matrix in which they are imbedded, and the usual tests for discriminating hornblende from dark mica cannot be applied

Some of the mica is evidently of secondary origin and replaces other minerals the crystallographic outlines of which remain

The slices contain some ilmenite Gas cavities, and liquid lacunæ are very abundant in the quartz At fig 14 I have depicted a liquid cavity containing what is apparently a corroded crystal of sodium chloride together with two bubbles, the larger of which is distinctly movable It is very unusual to meet with a plurality of bubbles in liquid cavities, but this case, and that represented at fig 23, show that such instances do occur

The porphyritic crystals of felspar are partly orthoclase and partly plagioclase They are much altered and kaolinized

The quartz crystals are in part rounded and are much corroded, containing the inclusions of the ground mass so characteristic of the quartz of quartz porphyries A sketch of one of them is given at fig 10 In the uncorroded portions the crystallographic form of the mineral is well preserved Many of the quartz crystals are fringed with a thin border of mica

The rock is a quartz porphyry on the border line of the granite porphyries

No 15 Sp G 2 60 —This specimen was taken from a tongue of the quartz porphyry dyke, above described, which protrudes into the adjoining rocks at right angles to the course of the dyke The matrix of this specimen is perfectly compact, even when examined with a lens, but the rock does not differ in other respects from that just described

M —The ground mass is micro-felsitic, but between crossed nicols it has a spotted, mottled appearance, as if it were made up principally of imperfectly developed granules of felspar

The porphyritic crystals of felspar are much decomposed and have to a considerable extent been converted into kaolin Here and there patches of chlorite and a mineral that looks like pinite occur in them Some of the felspars exhibit the characteristic twinning of the triclinic system

There are several large micas in this slice of greenish colour in transmitted light, but they are much corroded and eaten into The principal part of the mica present in the slice, however, exists rather in the form of micaceous matter than in well-shaped leaves or crystals, and is dappled over the ground mass in finely granular masses which exhibit no definite shape under the microscope, and only show dichroism, here and there, when in thicker masses than usual

Gas inclusions are extremely numerous in the quartz Liquid cavities with movable bubbles are less abundant than in the other slices of the quartz porphyry (Nos 9—14), and they are of smaller size

The slice is stained, here and there, red and yellow with ferrite, and contains a few small grains of magnetite or ilmenite

The porphyritic quartz crystals are to some extent corroded, but on the whole they exhibit sharply defined crystallographic forms

MM Fouque and Michel-Lévy in their *Minéralogie Micrographique* give expression to the view that the porphyritic crystals of quartz in quartz porphyry belong to the first epoch of consolidation, the partial rounding of the porphyritic crystals and the inclusion of portions of the ground mass by the quartz they

attribute to the corrosion of the crystals due to mechanical and chemical action [1]

A study of the rocks described in this paper has convinced me of the soundness of this view, and has satisfied me that the inclusions of the ground mass visible in the quartz crystals, in the specimens now described, are due to corrosion, or partial remelting, and not to imperfect crystallization consequent on rapid cooling

The matrix of the hand specimen taken from the thin tongue protruded into the adjacent rocks is perfectly compact, even when viewed with a powerful pocket lens, whereas that taken from the body of the dyke appears, under the same lens, to be micro-granitic rather than compact,—a difference attributable, I presume, to the fact that the thin tongue cooled more rapidly than the main dyke If the porphyritic crystals were formed after the intrusion of the quartz porphyry, one would expect to see a marked difference between those in the tongue and those in the main dyke, corresponding to the difference observable in the matrix of the specimens from the two localities One would, also, expect to see inclusions of the ground mass more common, and crystallographic outlines less frequent in the former than in the latter No such difference however is to be discerned Sharp well-defined crystallographic outlines are not rare in the quartz of the specimen from the tongue, whilst the crystals in the main dyke are quite as much corroded as any in the tongue.

Figs 8 and 10 of the plate attached to this paper may be usefully compared with fig 43, p 189 of MM Fouqúe and Michel-Levy's work above quoted

Felsites—Tushám

Ten thin slices taken from five hand specimens have been examined The specific gravity of the latter ranges as follows —

No 16	2 72
„ 18	2 76
„ 20	2 68
„ 22	2 68
„ 24	2 77

The specific gravity of No. 24 is rather high, owing to the large amount of magnetite present in the rock

The mean specific gravity of these five specimens is 2 71 The specific gravity of felsites according to J D Dana (Manual of Geology) ranges from 2 6 to 2 7 and according to B von Cotta (Rocks Classified and Described) from 2 5 to 2 7, that of the specimens described in the following pages, therefore, agrees well with the above authorities

Nos 16 and 17 —A compact rock of dull brownish-red colour mottled with dark grey With the aid of a lens, grains of free quartz are seen to be freely sprinkled about in the matrix Some mica and minute specks of iron are also to be seen

M —The ground mass is micro-felsitic Between crossed nicols the particles which show colour do not exhibit any tendency to that parallelism of arrange-

[1] See also Professor Judd's and Mr Cole's remarks in their paper on Basalt glass Q J G S., XXXIX, p. 459

ments which is so characteristic of slates The matrix is, as is often seen in quartz porphyries, blotchy in appearance, and is not of that uniform structure generally observed in slaty rocks

In ordinary transmitted light the ground mass appears to be formed of two magmas imperfectly blended together, which differ from each other sufficiently in colour to render the fluxion structure of the rock visible The comparatively colourless magma appears to contain more quartz than the buff coloured felspathic magma

In my paper on the gneissose granites of the North-West Himalayas, I noted an instance of grains of magnetite being involved in strings of red ferrite in a way to exhibit fluxion (See fig 14, Records, XVII, p 72)

In this slice a very similar instance occurs which I have sketched at fig 9 The red ferrite has evidently been derived from the magnetite, and then, in the way suggested in my last quoted paper, the ferrite and the magnetite have been drawn out into strings during the subsequent motion of the mass The ferrite has not, in this case, been formed *in situ* by the action of water flowing past the strings of magnetite Fig 9 should be compared with the description given in the paper referred to

The slices contained a considerable amount of magnetite and a little hæmatite or göthite

There are no porphyritic crystals of felspar, but crystals of quartz are numerous They are in part rounded and corroded, though several of them present very perfect crystallographic outlines The quartz contains numerous liquid cavities with movable bubbles and gas inclusions

Thin rounded microliths are abundant, here and there, in the ground mass, they are either colourless, or of very pale green colour, and exhibit no dichroism, their optical properties being overpowered by the matrix in which they are imbedded At times they radiate from a centre in a way that reminds one forcibly of the augite microliths of the pitchstone of Arran

Nos 18 and 19 —A dark grey compact rock with minute blebs of quartz visible here and there in it

M —The ground mass is micro-felsitic, and faint traces of fluxion structure may be made out in it. Porphyritic crystals of quartz are numerous Some of them exhibit very perfect crystallographic outlines, but others are rounded and corroded A few are in the form of prisms with pyramidal terminations

The slice contains one or two fragments of schorl What appear from their colour to have been crystals of hornblende are replaced by delessite or an allied mineral, quartz, and a little ferrite The delessite is also dappled about over the slice

A little magnetite is present, but it has for the most part been converted into red ferrite. There are one or two leaves of mica

The quartz contains air inclusions and liquid cavities with movable and fixed bubbles

Nos 20 and 21 —A light grey compact rock with minute facets of quartz visible here and there in it With a lens, some of these quartz crystals are seen to have very perfect forms, whilst others are rounded Little cavities have

been created, here and there, by the decomposition and removal of the iron The specimen very much resembles an acid lava in appearance

M —In general characteristics these slices are like those last described, except that they neither contain schorl nor delessite pseudomorphs, all trace of fluxion structure is also wanting Some of the porphyritic crystals of quartz in these slices are very remarkable objects, instead of being clear single crystals, like those in the other slices, they contain strings of muscovite microliths, and are compounded of countless granules of quartz This is all the more remarkable as the exterior crystallographic outline of these crystals is, in some cases, very sharply defined In the field of the microscope these compound crystals have a striking resemblance to the quartz of such granites as the gneissose granites of the North-West Himalayas, in which the quartz exhibits a polysynthetic structure, and in which muscovite microliths are often abundant The presence of compound crystal of this character is not inconsistent with, but is, on the contrary, explained by the theory that they belong to the first epoch of consolidation, for it is open to us to suppose that after the rock began to consolidate as granite it was put in motion and partially remelted

Magnetite, converted in part into red ferrite *in situ*, is abundant in these slices, and numerous specks of it are present in the compound quartz crystals above described

Liquid cavities with movable bubbles are plentiful in the quartz In one liquid cavity I observed an inner liquid globule containing a violently active bubble The liquid globule is probably carbon dioxide

Nos 22 and 23 — A dark grey compact rock, with minute blebs of quartz visible here and there It weathers to a light brown the weathered portion forming a sort of rind more than a quarter of an inch thick This is probably the rock called basalt in the Archæological Report (*foot-note, ante*)

M —The ground mass is micro-felsitic, and the porphyritic crystals consist of quartz and felspar Both plagioclase and orthoclase are present, but the crystals are not all fresh, many of the larger ones having been converted in part into a chloritic mineral There are also some crystals which appear to be pseudomorphs after hornblende, the latter mineral having been wholly converted into viridite The quartz crystals are, as usual, in part rounded and corroded, the other portions exhibiting sharp crystallographic outlines A sketch of one of these crystals, taken from this slice, is given at fig 8 This quartz was apparently at one time a prism with pyramidal terminations at both ends The lower pyramid has been wholly eaten away, the top pyramid has lost its apex, and one side of the prism has been deeply corroded The dotted lines in the sketch indicate the portions that have been removed

Nos 24 and 25 —A compact rock with minute blebs of quartz visible here and there It has a mottled appearance

M —The ground mass is, as in the case of the other specimens, micro-felsitic Fluxion structure is to be traced, but it is not marked

Magnetite is very abundant in the slice, being present in well-shaped cubes and octahedrons Many of these have been peroxidised into ferrite of a brilliant red colour without the loss of their characteristic crystallographic outlines The

magnetite and ferrite give evidence, in the way they are grouped and arranged, of the flow of the ground mass

These slices contain some leaves of a colourless mica, apparently muscovite, and a fragment of an altered mineral resembling hornblende

Quartz is the only porphyritic mineral in this slice It contains very numerous liquid cavities with bubbles and some gas cavities, also fine hair-like colourless belonites similar to those so often seen in the quartz of granite

Tusham granite

No 26 —A coarse-grained rock extremely rich in schorl and in muscovite

M —Owing to the friable character of the rock, only a thick slice could be obtained, so thick that the felspar and schorl are quite opaque The felspar is stained red and yellow with ferrite

The quartz and felspar are very much intergrown, and some of the smaller crystals of the former exhibit hexagonal outlines, showing that they belong to the first epoch of consolidation, and that the granite exhibits a transitional stage between a normal granite and a quartz porphyry

The quartz contains gas and liquid cavities

No 27 —This specimen generally resembles No 26, but a black mica is substituted for muscovite. It is present in considerable abundance, but in small packets Schorl is absent This rock which comes from a different part of the hill to No 26 is so friable that only a very thick slice could be made It is so thick that no observations worth noting could be obtained under the microscope

Hills near Tusham

No 28 —A fine-grained granite composed of felspar, quartz, and black mica

M —The felspar is of two, if not three kinds plagioclase and orthoclase are both present, whilst the foliated mineral, described in detail further on, and which I regard as microcline, is abundant

Quartz of both the first and second epoch of consolidation is present, the former is in polyhedric grains mixed up with or enclosed in other minerals One caught up in felspar is a perfect prism with pyramidal terminations at both ends, whilst many others give more or less perfect six-sided sections The quartz of the second epoch of consolidation is in large grains moulded on the other minerals Globules, or rounded disks of quartz, are abundantly scattered through the ground mass These disks are very characteristic of these rocks and of the Khának and Deosir granitoid quartz porphyries, to be described in the following pages Sometimes they are seen to be merely thin disks without any tangible thickness, for they are seen to overlap each other, as in the south-east enclosure of fig 5, or to lie one upon the other, as in the south-west enclosure of fig 5, presenting in the latter case the appearance of an inclusion within an inclusion Fig 5, alluded to above, is a grain of quartz in this slice containing globulites, magnified 250 diameters

Grains of quartz are often stuffed with these disks, as represented at figs 7 and 15, both of which are taken from slices Nos 28 and 29 The felsitic ground mass contains multitudes of them, and some, if not all, must belong to the second

epoch of consolidation, for they frequently dwindle rapidly in size as they approach the edge of porphyritic crystals of felspar Fig 6 is given to illustrate this tendency The sketch represents a portion of the felsitic ground mass, the lower or southern margin of which abuts on a large felspar crystal which appears to have exercised an influence on the formation of the globular disks comparable with that of stratified rocks on sheets of basalt intruded into them, a dwindling in the size of the basaltic crystals being frequently observed towards the edges of intruded sheets

That the globular disks, however, were not the last mineral to crystallize is clear, for masses of them are sometimes included in felspar crystals and are arranged in lines which conform rigidly to the crystallographic form of the felspar

The mica appears to be biotite, and some magnetite is associated with it

Gas cavities predominate over liquid cavities, but the latter are also present in some abundance Many of the cavities are in polyhedric forms At fig 1 I have depicted one of imperfect hexagonal shape containing a cube of sodium chloride and a movable bubble

Some of the quartz contains hair-like microliths of schorl

This specimen approximates to a true granite

No 29.—A pinkish fine-grained granite The pinkish colour is due to the rosy tint of much of the quartz Some of the felspar is of dull greenish colour Black mica is abundant

M.—This appears to be a transitional form between a normal granite and a granite-porphyry

The magma is composed of an extremely fine-grained mixture of quartz and felspar The quartz is, for the most part, in rounded globules, which vary greatly in size, some being mere dots, whilst some here and there, especially when crowded closely together, present imperfect hexagonal outlines They remind me much of the fish-roe grains of the Dalhousie gneissose granite

In the ground mass, large crystalline fragments of felspar, quartz and leaves of dark mica, resembling biotite, are imbedded

The mica was evidently formed after the micro-crystals of quartz, for it encloses granules of that mineral and it is moulded upon other grains of quartz, some of which present hexagonal outlines

Orthoclase, plagioclase, and microcline are present, the latter, which is typically developed, is abundant It occurs both as a component of the ground mass and in large crystals None of the felspar presents external crystallographic outlines

Rounded and hexagonal grains of quartz of moderate size, which form a portion of the magma, and crystals of felspar, are stuffed with minute rounded globules or disks of quartz, like eggs in the roe of a fish, whilst some of these globules of microscopic proportions themselves contain other globules still more minute.

Some of the quartz grains contain tabular inclusions of red ferrite, probably hæmatite, and to its presence I attribute the rosy tints of some of the quartz grains when viewed macroscopically

One of the grains contains hair-like microliths that may be rutile

Liquid cavities are numerous in some of the large quartz granules, whilst gas cavities are abundant in all Some of the cavities contain a fixed bubble and deposited mineral matter of various kinds

One of the felspars contains a leaf of muscovite

The Khának hills 3 miles north-west from Tushám

No 30 —A fine-grained granite of whitish colour speckled with black Black mica is abundant

M —Triclinic felspar crystals are numerous, and equal, or nearly equal, in number those of orthoclase Microcline is not present The quartz belongs to two epochs of formation Moderately sized grains, many of which exhibit six-sided figures, and some of which are enclosed in felspar, are present, and also large pieces of quartz moulded on the other minerals

The slice contains numerous small garnets, and some apatite The quartz abounds in liquid cavities with movable bubbles, gas cavities and liquid cavities with gas bubbles One enclosure is a very interesting one, it contains an abraded cube, apparently of sodium chloride, a globule of liquid containing an inner bubble, and other inclusions The liquid globule seems to be carbon dioxide Another enclosure contains a bubble and three crystals, whilst a third contains two bubbles, one a large gas one, and the other a small one of normal type

Hair-like belonites are present in the quartz and microliths containing gas and other cavities

The slice contains a good deal of magnetite or ilmenite for the most part associated with the dark mica

No 31 Sp G 2 62 —A dark grey coloured rock, in which crystals of felspar, quartz and black mica are thickly imbedded in a grey compact matrix

M —The ground mass is micro-felsitic and shows some feeble traces of fluxion structure It contains orthoclase, plagioclase, and quartz porphyritically imbedded in it The quartz is rounded and corroded as in quartz felsites The slice contains numerous garnets

Mica, brownish green in transmitted light, is very abundant The leaves are grouped together, and some of them are well foliated

This slice, Nos 28 and 29, and the other specimens about to be described, contain a mineral regarding which I have felt considerable doubt It is either colourless or has the faintest possible brownish yellow tint in transmitted light It exhibits no dichroism and polarises in brilliant colours more suggestive of pyroxene than microcline It presents a very finely foliated appearance, perfectly straight and parallel lines traverse it, and are so crowded together that about 200 of them may be counted in a single piece. Coarser but interrupted cleavage lines, in some specimens, cross these at an angle of about 82° The negative axis is at a high angle (from 80° to 90°) from the fine lines The mineral is superficially corroded here and there, after the manner of felspars, and the corrosions exhibit a strong tendency to run with the fine lines

None of the pieces possess crystallographic outlines sufficiently definite or characteristic to help one to determine the nature of the mineral

Between crossed nicols the mineral generally presents an unbroken sheet of colour, but occasionally the fine parallel striæ exhibit colourless streaks between the lines of colour, but this is apparently the optical effect produced by the cleavage planes on the transmitted polarised light, and is unlike the appearance produced by the multiple twinning of triclinic felspars Moreover, in the case of triclinic felspars, the negative axis is at a comparative low angle to the twinning planes

Pyroxene is sometimes found in granitic rocks (J D Dana's Maunal, p 219) and diallage has been observed in some granulites composed of diallage, triclinic felspar, quartz, garnet, and biotite (Geikie's Text-Book of Geology, page 125) Viewed macroscopically, however, I can discover nothing in the hand specimens suggestive of pyroxene,—what is not quartz appears to be felspar

In my paper "On the Microscopic Structure of some Dalhousie rocks" (Records, XVI, p 131), I noted the occurrence of a fibrous felspar in those rocks, and quoted from Zirkel's Microscopical Petrology of the 40th Parallel a notice of a similar felspar which occurs in the American rocks

The mineral now described differs from the Dalhousie one in that the fine parallel lines in the Arvâli mineral look less like fibres than cleavage planes, but still I think, on the whole, that the mineral before me can only be a variety of microcline

The slice contains magnetite or ilmenite A microlith, apparently of quartz, contains a liquid cavity, with a movable bubble

The quartz contains the usual liquid cavities

The microscopic examination of this slice shows that the rock is a quartz porphyry approaching to a granite porphyry

No 32 —This specimen closely resembles the last, but the amorphous paste is, perhaps, less abundant

M —Under the microscope this rock presents much the same appearance as the last The porphyritic crystals of quartz and felspar are rounded and corroded, and contain inclusions of the ground mass The fibrous felspar (microcline) is abundant Flakes of mica are scattered through the ground mass in great numbers

Nigana hills, 7 miles south from Tushâm

Nos. 33-38 —A pinkish rock closely resembling a granite The felspathic ground mass is in this specimen at its minimum

M.—These slices present the general characteristics of the Khának rocks Liquid cavities containing vacuum and gas bubbles are abundant Some of the cavities are of hexagonal shape A great many of them contain deposited minerals as well as bubbles One, containing three cubes and a bubble, is depicted at fig 2 I also observed a microlith containing a stone enclosure

Microliths, probably of schorl, are abundant in the quartz

As in the other Khának specimens, globules of quartz, some of which are of imperfect hexagonal form, are abundant

Deosir, an isolated hill, about 4 miles south-west from Bhiwáni

Nos 39-41 —A fine-grained granite of grey colour composed of quartz, felspar, and black mica. Viewed macroscopically this appears to be a perfect granite

M —Under the microscope, this rock is seen to possess a micro-crystalline ground mass, in which large crystals of felspar, quartz, and biotite (?) are imbedded The ground mass consists of a felspathic base in which myriads of quartz globulites are scattered about Most of them present more or less rounded outlines, but some are roughly hexagonal or four sided in shape

There are some micro garnets, and a little schorl, blue in transmitted light, is seen in one of the slices

Porphyritic crystals are present which exhibit crystallographic outlines in part, whilst other portions of them are rounded, and contain inclusions of the ground mass

Plagioclase and orthoclase are both present The latter is very glassy and is undistinguishable from sanidine

Liquid cavities with bubbles are very numerous in the quartz, and many of them contain deposits of sodium chloride or other cubic salt One containing a cube of the latter also contains a red liquid globule with an inner bubble In some, as in the case depicted at fig 3, the crystalline deposit nearly fills the whole cavity In another case, see fig 4, gas and a crystalline deposit are included in the same cavity These examples appear to indicate conditions of intense heat and great consequent solvent capacity in the liquid and gas Some of the cavities are of rough hexagonal shape

The ground mass contains numerous dots of opacite Fine hair-like microliths are common in some of the quartz

Hissar City Wall

Nos 42-43 —The wall of the town of Hissar is built of blocks of rock from the neighbouring hills of Khanak or Nigana The thin slices examined do not differ from those described in the preceding pages

Conclusion

When I commenced the microscopical examination of the rocks described in the preceding pages, I though it probable that some affinity would be detected between the Dosi syenitic granitoid gneiss and the granitoid rocks of Nigana, Khának, and Deosir, but they proved to be altogether different

In the Dosi rock hornblende is a prominent feature, whereas in the rocks with which it has been compared, there is scarcely a trace of that mineral

The Dosi rock, moreover, is of granitic structure, whereas the Khanak rock, and its allies are quartz porphyries more or less approximating to, but never becoming, true granites

In point of age there is probably a wide gulf between them What the precise geological age of the Khának group may be, it is impossible to determine from the examination of the Tusham region alone, as the Khanak rocks and their allies form isolated hills—small islands as it were—rising from a sea like expanse of post-tertiary sandy soil, the long swelling waves of which, formed into a series of crests and troughs by the prevailing westerly winds, break like the swell of the ocean on their rocky shores

Whether the Dosi syenitic granitoid gneiss is or is not an igneous rock is a question which must remain for the present an open one It has its allies doubtless further south, and the question must be decided in connection with them Certain it is that the Dosi rock contains internal evidence of having been reduced by aqueo-igneous agencies to a fused condition, and it does not differ in internal structure from some Scotch eruptive rocks with which it has been compared These circumstances, however, are not in themselves sufficient to determine the question The examination of the Delhi quartzite, detailed in this paper, shows that this rock also, regarding the sedimentary origin of which I presume there can be no doubt, was subjected to intense aqueo-igneous heat and reduced to a plastic condition

The microscopical examination of the Delhi quartzite is most instructive, for it shows that whilst we have at the one end of the metamorphic scale such rocks as the micaceous schist intercalated with unaltered limestones of the carbo-triassic series, alluded to in my paper on the gneissose granites of the North-West Himalayas, the metamorphism of which has evidently been brought about by aqueous agencies which required little heat for their accomplishment, at the other end of the scale we have very ancient rocks like the Delhi quartzite which have been subjected to intense plutonic heat

The Delhi quartzite, moreover, shows that evidence of fusion, taken alone, is not sufficient to enable us to say definitely whether a rock which exhibits it is an eruptive or a metamorphic rock

Evidence of fusion, however, is a point, the significance of which can hardly be over-estimated Combined with other evidence which would not in itself be conclusive, it may place the eruptive character of a rock beyond doubt, whilst, in doubtful cases, evidence of igneous fusion would, I think, narrow the issue to be determined to the question whether the rock under examination is an igneous one or a metamorphic rock of extreme geological age

Plutonic heat sufficient to reduce such a rock as a quartzite to a fused condition must have occurred at a great depth, and a rock so deeply buried must have required ages to come to the surface Hence evidence of igneous fusion in a metamorphic rock affords a strong presumption of great geological age

The difficulties which some geologists feel in believing in the existence of other than archæan metamorphic rocks may possibly arise, it seems to me, from not sufficiently discriminating between plutonic metamorphism, like that exhibited by the Delhi quartzite, and the hypo-metamorphism of such rocks as the carbo-triassic mica schist, previously alluded to, which may be produced by aqueous agencies near the surface, without much heat, and which does not connote archæan age

But to return to the Arváli rocks Whilst I do not consider it desirable, for the reasons given above, to pronounce a definite opinion regarding the Dosi syenitic granitoid gneiss, on the other hand the microscopic examination of the Tusham, Khának, and Deosir rocks has satisfied me that many of these, which I previously regarded as probably of metamorphic origin, are really eruptive rocks

The chiastolite schists and the indurated clays on the eastern flank of Tushám are of course sedimentary beds, but the rocks which compose the centre and

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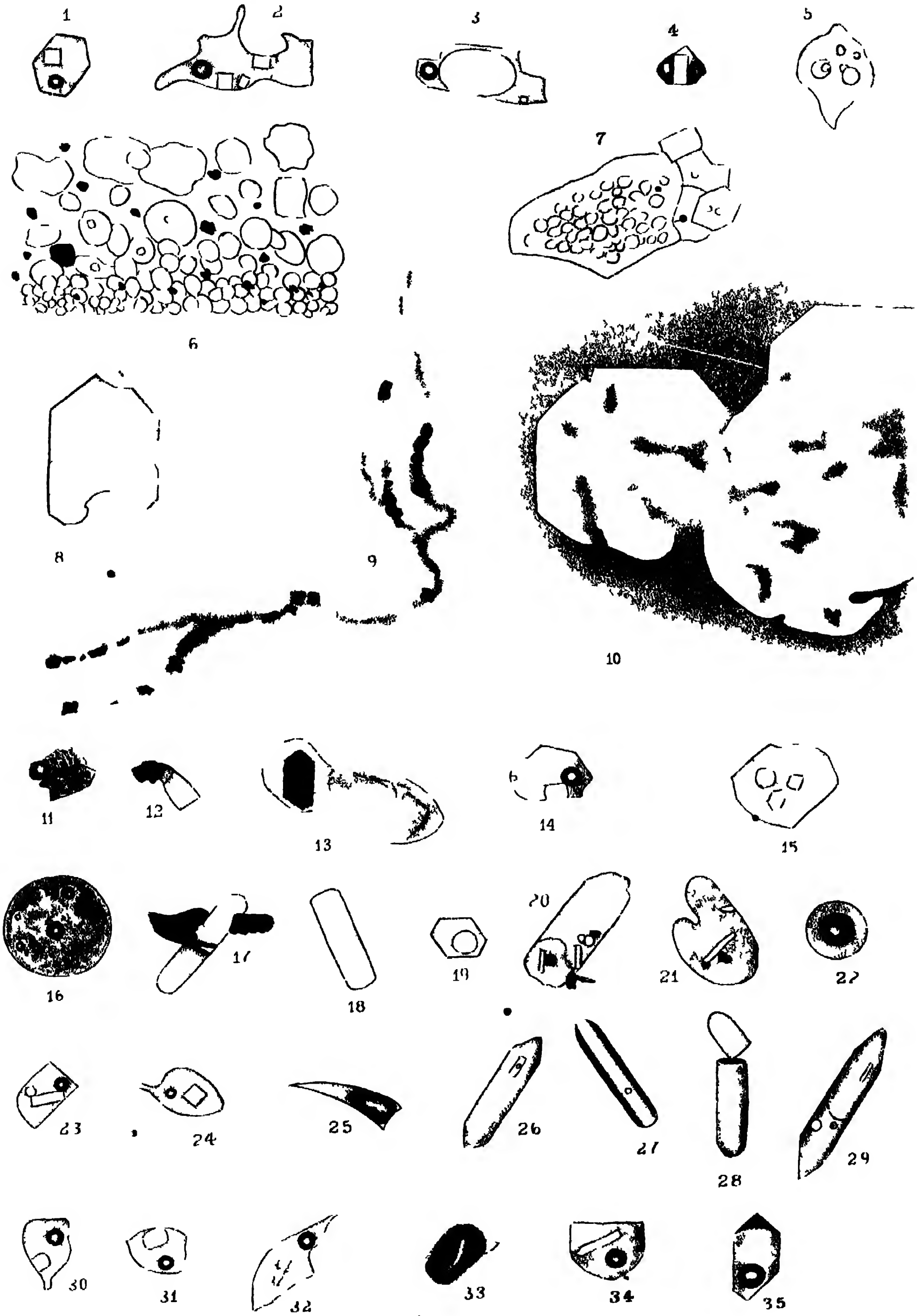
McMahon Arvali rocks

Records Vol XVII



T Schaumburg Lith.

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the western flank of the hill prove to be felsites or micro-quartz-porphyries, which contain internal evidence of their eruptive origin in the shape of fluxion structure and other structural peculiarities

The Tushám rocks are penetrated by granite bosses and veins and by quartz porphyry dykes which are undoubtedly intrusive

A little hill close to Tusham and the hills of Khának, Nigána, and Deosir are evidently closely allied to the granite, the quartz porphyry, and the felsites of Tusham Viewed macroscopically these rocks at first sight look like granites, but the aid of a pocket lens enables one to detect more or less amorphous paste in nearly all of them Under the microscope they are seen to be quartz porphyries, which shade towards the granite porphyries on the one hand, and towards the felsites on the other Indeed the felsites of Tushám are micro-quartz-porphyries Under the microscope they are seen to be of precisely the same structure as the Tusham quartz porphyry, the only difference being that in the former the grain is of microscopic fineness, and the porphyritic crystals extremely minute, whilst in the latter, the porphyritic crystals are of large size, and the distinction between them and the amorphous ground mass is visible to the unaided eye

The Nigána, Khanak, and Deosir rocks are also essentially quartz porphyries in their structure, but the porphyritic crystals are in size intermediate between those of the quartz porphyries and the felsites of Tusham The amorphous paste (ground mass), however, is relatively small in amount, and the resulting rock approximates in appearance to a granite That they are all eruptive rocks, and all more or less connected with each other, I see no reason to doubt Fluxion structure, and the presence of minerals of the first and second epochs of consolidation, the former of which have been partially rounded, corroded, and eaten into, as in figs 8 and 10 of the plate attached to this paper, seem to me to offer decided indications of their eruptive origin

DESCRIPTION OF THE PLATE

Fig 1 —A liquid cavity of imperfect hexagonal form, containing a movable bubble and a cube of sodium sulphide Granitoid quartz-porphyry from hill near Tushán Slice No 28

Fig 2 —Liquid cavity containing deposited minerals and a bubble Slices 33—38 Granitoid quartz-porphyry Nigana hills

Fig 3 —Crystalline deposit nearly filling a liquid cavity Granitoid quartz-porphyry Deosir Slices 39—41

Fig 4 —Crystalline deposit in gas cavity *Ib*

Figs 5, 6, and 7 —Rounded granules and disks of quartz scattered through the ground mass (fig 5), and enclosed in quartz grains (figs 5 and 7) Slice No 28 Granitoid quartz porphyry Hill near Tushám

Fig 8 —Quartz crystal in part rounded and corroded Slices 22 and 23 Felsite Tushám

Fig 9 —Grains of magnetite involved in a string of red ferrite Slices 16 and 17 Felsite Tushám

Fig 10—Quartz crystal partially rounded and corroded Slices 9—14 Quartz porphyry Tusham

Fig 11—An air bubble attached to minerals Slices 5—7. Delhi quartzites

Fig 12—Opacite drawn towards and attached to a microlith, *Ib*

Fig 13—An opaque crystal embraced by a flake of mica *Ib*

Fig 14—Liquid cavity with the bubbles (right hand one is movable) and a corroded crystal of sodium chloride Slices 9—14 Quartz porphyry Tushám

Fig 15—Rounded disks of quartz and dots of opacite enclosed in a quartz grain Slices 28 and 29 Granitoid quartz porphyry Hill near Tushám

Fig 16—Coloured stone enclosure containing four fixed bubbles in the quartz of the Dosi syenitic granitoid gneiss Slices 1—4

Figs 17 and 18—Microliths containing shrinkage cavities Opacite has formed on that in fig 17 Slices 5—7 Delhi quartzite

Fig 19—Liquid cavity of hexagonal shape containing a globule of liquid carbon dioxide and inner movable bubble Delhi quartzite *Ib*

Figs 20 and 21—Microliths (20 of quartz and 21 of mica) which have caught up micro-crystals and opacite Delhi quartzite *Ib*

Fig 22—Air or gas bubble surrounded by a ring of coloured mineral matter Delhi quartzite *Ib*

Fig 23—A liquid cavity containing a crystal and two bubbles, the right hand one being a movable gas bubble Dosi syenitic granitoid gneiss

Fig 24—Liquid cavity containing bubble and crystal from the quartz of granite invading lower silurian rocks Aberdeen

Fig 25—Enclosure containing gas *Ib*

Figs 26, 27, 28, and 29—Micro-crystals containing liquid cavities and shrinkage cracks in the Aberdeen granite referred to under fig 24

Figs 30, 31, and 32—Liquid cavities in the Dosi syenitic granitoid gneiss in which crystals have been deposited on cooling The cavities also contain bubbles

Fig 33—A gas inclusion in a liquid cavity *Ib*

Fig 34—Another liquid cavity in which a crystal has been deposited on cooling *Ib*

Fig 35—A liquid cavity in quartz which has taken the shape of a quartz crystal The enclosed liquid contains a movable bubble *Ib*

Section *along the* Indus *from the Peshâwar valley to the Salt-range, by* W Waagen, Ph D, F G S[1]

Having just returned from a little trip from Kálabágh up the Lun Valley to Kohat, and from there over the Kotal Pass into the Peshâwar valley, then back over the Meer Kulan, Pallosi, and Sundully Passes to Shadipur and down the Indus to Kálabágh, I hasten to communicate to you some of the results, as far as I am able to point them out here in the field

[1] The figured section, with the brief description now published, was communicated to Dr Oldham in the form of a letter some 12 years ago, when Dr Waagen was attached to the Geological Survey of India As an accurate representation, so far as the scale would admit, of a most inter-

One of the most interesting parts of the whole excursion certainly was the returning road down the Indus, as this exhibited an uninterrupted section from the oldest to the youngest formations of the whole country, and it is principally this section, of which I send you enclosed a drawing, which I intend to describe more accurately

Starting from Julozai in the valley of the Cabul river, one has to traverse first a rather extensive plain, consisting entirely of debris, mostly of a red sandstone and marl mixed with fragments of black slate and quartzitic sandstone As soon as one reaches the skirts of the hills down in a little ravine, a yellowish limestone with great masses of greenish flaggy shales and slates below crops out The slates continue, changing their colour slowly into black, and then mixed with dark, extremely hard quartzitic sandstones After about 2 or 3 miles marching, down in a deep glen, suddenly a light-coloured limestone appears, as if dipping under the slates, which are exposed to an enormous extent on both sides of the glen After a short search, nummulites were detected in this limestone, which is, however, not more than about 10 feet in thickness, being then already followed by red sandstones and shales, nearly quite vertical Though the red colour prevails in these rocks, there are also some thick pale green bands in it, which, however, do not influence the general red aspect of the whole formation The thickness of this formation is very great, though not so much as that of the slates, and at several horizons in it thin bands of nummulitic limestone are to be met with The road winds then up out of the bottom of the ravine, and then again nummulitic limestone appears, here nearly horizontal, forming a crest, and apparently lying regularly above the red formation The nummulitic, however, is lost soon again, and the red sandstones and shales, here locally almost vertical, are the rocks, over which the path winds up further on Descending into the glen on the other side of the pass, the red formation is replaced by dark shales, in some layers filled with the impressions of fossils, among them very numerous impressions of nummulites They rest upon thick hard grey limestones, in which nummulites could not be detected, though they may yet belong to this formation The bungalow lying on the scarp of the glen is built on these limestones Below them follow first again dark shales, then a light-coloured flaggy limestone, contorted like the Flysch along the northern base of the Alps, then again shales, and then a thick zone of white and light grey quartzites, resting on a formation of greenish or greyish slaty shales of several hundred feet in thickness No trace of fossils could be detected in all those layers Below this, grey limestones in thick banks are sticking out, but also here fossils are extremely rare, and no characteristic species was obtainable Sections of shells are visible on the weathered surfaces, and in some places I saw Entrochi of a little sharp angular Pentacrinite Under these again a thick mass of brownish coloured slaty

esting section, it is well worthy of record, showing a continuous section of the immense sequence of tertiary rocks lying between the Himalayan elevation and the outlying remnant now left in the Salt range, of what were probably the ancient fringing deposits of peninsular India The interpretation given of some points of the section may perhaps be open to question, but this scarcely interferes with the admirable view presented of the prodigious movements that have affected this enormous accumulation of tertiary strata The elevation of the Peshawar plain at Attock is only 1,100 feet, and that of Kálabágh about 700.—H B M

shales is lying, with lenticular portions of a beautiful oolitic grey limestone in it, then, just above the village follow white lithographic limestones without any fossils, then again slaty shales

After having crossed the valley of a little river the way again ascends to the Pallosi and Sundully Passes, which both in reality form only one Pass, crossing the range of mountains of which the Nilab Gash is the highest point in British territory On the north foot of the hills, yellow marly limestones, dipping at a low angle to the north, and containing casts of a large Lucina and some Gasteropods appear, then follow compact nummulitic limestones in great thickness, dipping here to the south, but further on much contorted In fact the whole range chiefly consists of these limestones, and only in the deeper cuttings of valleys or ravines, older formations appear So, looking down from the height of the Sundully Pass, a rather thick system of limestones, sandstones, and shales, on the whole of a brownish-yellow aspect, is observable We were prevented by rain and the short daytime from going down and examining the beds closer But from fragments found before in the river, and from the beds observed by Mr Wynne at another locality, it seems that cretaceous and jurassic, certainly mesozoic, deposits are here represented On the other side of the valley nothing of those formations is observable, but instead of that a red band runs along the foot of the steep scarp of the nummulitic limestone

The southern slope of the range is very steep, and the first descent is entirely occupied by nummulitic limestone, then there is a sudden change in colour, and the whole country appears as if looked at through a red glass In the beginning just at the foot of the hills, between the purplish-red layers, a few bands of yellow marly nummulitics are still observable, but they are only few in number and very thin Further on purplish-red sandstones and marls compose exclusively the rocks along the road, only sometimes there appears a greenish zone, the layers are fearfully contorted and dipping in every direction A short distance before reaching Shadipur the red colour is lost again, thick soft grey sandstones here cropping out, only seldom interrupted by a purplish marl band

At Shadipur I took a boat, and during four days going down the river I observed the following section At Shadipur the grey sandstones appear along the river bank, dipping to the south, then the purplish-red series comes in again inexpressibly contorted, and two or three miles further down a band of nummulitic limestone, with vertical bedding, crosses the river Behind this a little valley, filled up with unconformable conglomerate, comes down to the river, and conceals the junction between the nummulitics and the next series, the same grey sandstone with a few purplish marl zones, upon which Shadipur is built The layers, however, are here nearly all vertical, sometimes inclined a little to one or the other side This again lasts for several miles, the contortions become less strong and so better visible, suddenly thick marly layers of a red colour appear, mixed with rather thin beds of grey sandstone To mention all the contortions of these and all the following layers is utterly impossible, and I can in this respect only refer to the drawing, which I have made after nature, and which may give a general idea of the features of stratification A comparatively short distance further on, the red marls and grey sandstones are checked by a fault against a

very extensive series of purplish marls with subordinate but often very thick grey sandstones, about in the middle of which Kushialgurh is built on a sandstone reef

This purple series lasts yet for a long distance below Kushialgurh, but then it finishes at a little valley which comes down to the river, on the other side of which suddenly red marls appear, dipping under a rather low angle to the south The sandstones between these marls are grey, as elsewhere in the Indus section The colour of the marls, going further down the river, rapidly changes into brick-red, and near the rapid at Kasab the red colour is most striking A short distance below Pres, the river turns to west 30° south and runs for about 6 miles in a beautiful channel nearly in the strike of the beds, which is with a very remarkable constancy from Shadipur down to Mirzapur at the mouth of the Soh́an river, west 20° south —east 20° north The river flows for a very long way through the red series, only at the short turn before arriving at the last rapid, the colour of the marls changes suddenly into orange and green, and then follows a very thick pale yellowish-grey sandstone in enormously thick beds, only rarely interrupted by orange marls In the upper region the sandstone contains layers of conglomerate, consisting of pebbles of beautiful crystalline, metamorphic or eruptive rocks The conglomerate beds become more and more numerous, and at last the rock changes into a very extensive mass of conglomerates, in which limestone pebbles are nearly entirely unknown

Further on the thick sandstone, which I shall call Dungote Sandstone, after the Dungote Hill, which is entirely formed of it, comes out again, and below it the orange series, both dipping to the north, then a short span of very contorted orange beds, and then again the conglomerates, faulted against the former The bedding now quickly changes to nearly horizontal, about Makhud Below Makhud the Dungote sandstone comes a third time above the level of the river, sometimes containing a bed of conglomerate, the decomposition of which has covered the whole country with a rather thick sheet of perfectly rounded pebbles of crystalline rocks

Coming near the mouth of the Sohán river in the vicinity of the hill tract in connection with the Salt-range, the stratification of the rocks is again disturbed, the layers are turned up, dipping to the north, and the orange series appears below the Dungote sandstone in a broad zone A fault just below Dungote Hill brings the sandstone again down to the level of the river, a little further on, after several faults, the orange series forms the sides of the cutting the river has made through the hills, down to the Lun river valley. Below this, the rock-salt, gypsum, and red marl of the Kálabágh and Mari hills form the river bank In the Kálabágh hill a part of the orange series lies unconformable upon the salt and gypsum, and above this again unconformably a thick conglomerate, consisting nearly exclusively of calcareous pebbles Kálabágh itself stands upon highly tilted layers of sandstone with conglomerates of crystalline pebbles

Such is in rough outline what I have seen The more difficult task, however, is to arrange all the divisions I have distinguished into a chronological scale, and to discuss their relations to each other I begin with the undoubtedly youngest of them the

(1) Unconformable Conglomerate This formation is spread over the whole Rawal Pindi plateau in more or less extensive patches, and I have marked it in the section at several points at Kálabágh, below Res, below and above Kushialgurh, and below Shadipur It nearly always consists chiefly of calcareous pebbles It has partaken in the disturbances of the older beds, so far as I know, only at Kálabágh, where it is erected vertically in some places Of about the same age, or a little older, may be certain clayey sands of a white or yellowish colour, which I have marked below Kushialgurh

Undoubtedly older than No 1, but following immediately below it in the scale of our section, is the

(2) Conformable Conglomerate This formation shows the best development in the hills above Makhud, where it is exposed to an enormous extent all along the river It appears again near Makhud itself, but nowhere again to the south or to the north It is chiefly consisting of crystalline pebbles, and is intimately connected with the underlying sandstone, is disturbed entirely in the same way as this, and actually passes down into

(3) Dungote Sandstone A pale yellowish-grey more or less soft sandstone of about 2,000 feet in thickness, alternating commonly with layers of conglomerate in the upper and orange marl beds in the lower part A part of the hills above Makhud and the greater part of the Dungote hill range is formed by this sandstone, its most extensive development is, however, further west from the Indus.

(4) Orange Series There is a perfect transition from the sandstone above into this series. The principal rocks are grey sandstones interstratified with partly very thick beds of often very bright orange and grey coloured marls This series is found resting unconformable upon the rock-salt and gypsum at Kálabágh, all the hills between the Dungote ridge and the Lun valley consist of it, it appears north of the Dungote hill, and north and south of the hill range above Makhud everywhere in intimate connection with the Dungote sandstone The thickness of this series is only in some parts considerable

(5) Red Series By alternation of red with orange beds, the series before described passes into this The marls are here very much prevailing over the sandstones, and of a bright brick-red colour In our section this series is only represented north of the conglomerate hills near Res and Kasab, and for a short distance between Kushialgurh and Shadipur At the latter place it passes down into the

(6) Grey Sandstone Series, consisting of thick grey sandstones with rare marl beds of grey and purple colour This series occurs at Shadipur, and to a greater extent below this village Its relations to the next bed are nowhere sufficiently clear to determine from a stratigraphical point of view the age of this series, but as in the next division already nummulites occur, there is no doubt that it must be older than all the rocks as yet mentioned, and one can therefore safely suppose that the grey sandstone with purple marls passes down into the

(7) Purple and Murree Series I put these two series down together, though their appearance is not entirely identical, as both series contain in small bands nummulitic limestone Their chief difference consists in the sandstones, which are in the former grey, in the latter purple The purple series as developed in

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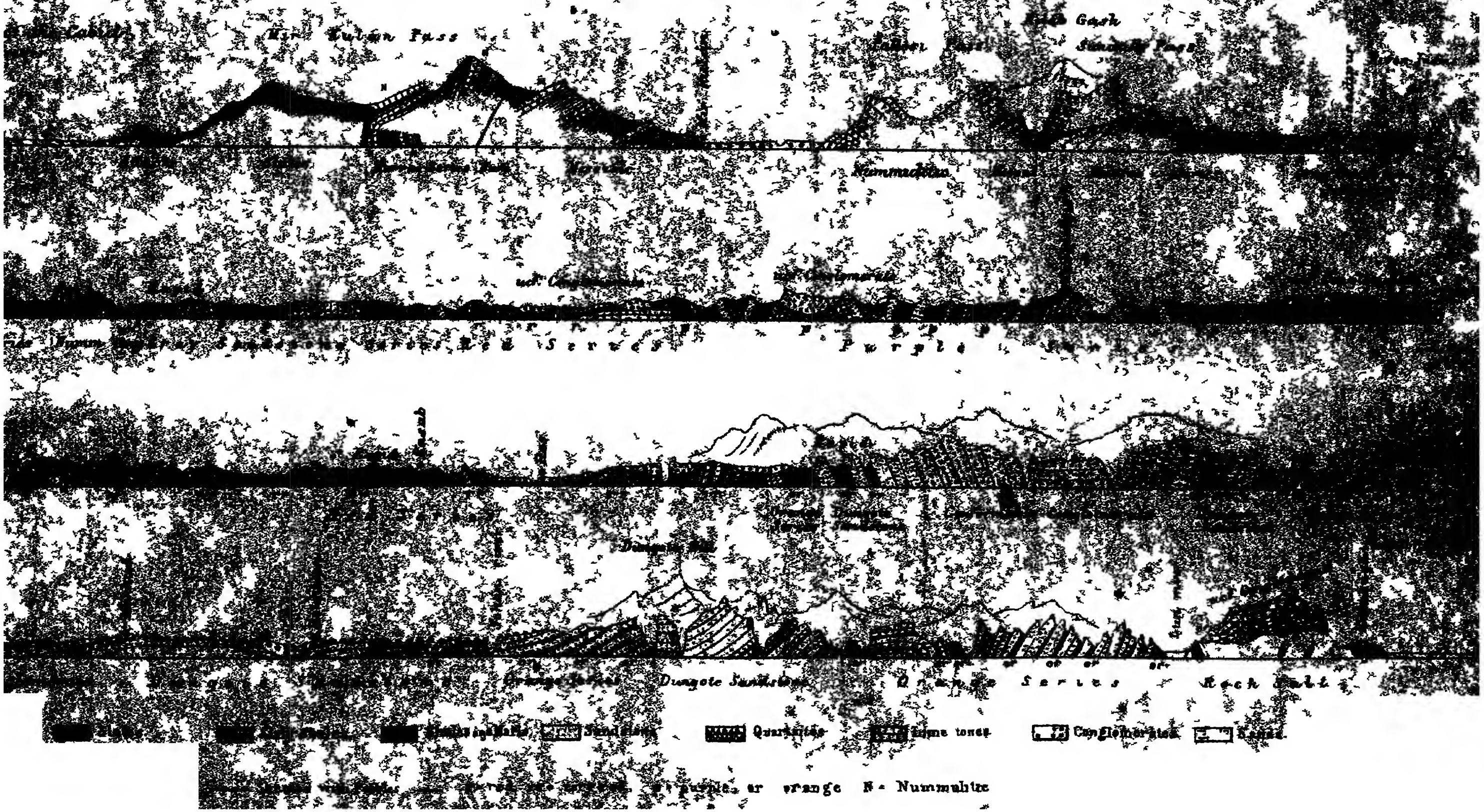
SKETCH SECTION FROM JULOZAI IN THE CABUL RIVER-VALLEY TO SHADIPUR AND FROM THERE ALONG THE INDUS TO KALABAGH



the country round Kushialgurh shows no nummulitic band, but in the direct strike of the beds, in the vicinity of Goorgoorlot Sir, I collected a great quantity of nummulites in them The Murree series with purple sandstones is developed north and south of Shadipur, and in the centre of the Mir Kulán Pass The stratigraphical relations of this series to the nummulitic limestone are extremely difficult its layers stand vertical at the side of nummulitic limestone south of Shadipur, they seem to dip under the latter at Sundully Pass, and lie above the oldest nummulitics on the Mir Kulán Pass That their position is certainly not below the great mass of compact nummulitic limestone is shown clearly by the Pallosi Pass, where the limestone lies immediately above the mesozoics without the Murree series between It is therefore for me no doubt that the Purple and Murree series are the youngest nummulitics passing up without interruption into younger tertiary and diluvial deposits

(8) Nummulitic Limestone Developed to a great extent in the Niláb Gash range, the southern part of which is pushed over the Murree series in a very similar manner as the Alpine limestone is pushed over the Flysch along the northern foot of the Alps The lowest division of the nummulitics consists of brown shales, which are exposed at the Mir Kulan Pass In this latter range the lower nummulitic limestone (above the shales) does not come into the section, but is well developed further to the west

(9) Mesozoic The rocks and whole development of these formations is so strange in this country, that I must abolish for the present any attempt to go into particulars about them That those beds are mesozoic is not doubtful, as the want of nummulites and the fragments of belemnites in fallen pebbles in the Pallosi pass very strongly indicate

(10) Attock Slates As neither fossils are found, nor do the stratigraphical relations reveal anything, I am utterly at a loss as to the determination of their age About the age of the last formation, the

(11) Rock Salt, I shall report another time

On the selection of Sites *for* Borings *in the* Raigarh-Hingir Coal-field *First notice, by* WILL KING, B A, D Sc, *Officiating Superintendent, Geological Survey of India* (With a map)

I —The Country and the Rocks
II —Division into Boring Areas
(*a*) The Lillari Valley Tract.

I —The country selected for this exploration lies about 22 miles north-north-west of Sambalpur, being partly in the Raigarh and five other smaller zemindaries of that district, and partly in the Hingir dependency of the Gangpur tributary state of Chutia-Nagpur Its geology and much of its coal capabilities have been already described[1] by Mr V Ball (late of the Geological Survey), and the occurrence of coal was known[2] to Captain Saxton so far back as 1855

[1] Rec, G S I, IV, pp 101 107 (1871), VIII, pp 102 121 (1875), and X, pp 170 173 (1877) Also, Manual of the Geology of India, Part I, Chap V, p 128, Chap IX, p 208, and Part III, Chap II, p 89

[2] A Statistical Account of Bengal (W W Hunter), Vol XVII, p 190

Although more than twelve years have elapsed since Mr Ball's first report was made, it is only now that the more practical development of this field is being taken in hand owing to the renewed proposals for increased railway communication between the Central Provinces and Calcutta It will therefore be some satisfaction to this geologist, after his unpromising labours in such an isolated and difficult tract as this is, as also to his predecessors in this field, to know that this line of railway will traverse the Hingir plateau It is practically to meet the requirements of this section of the Bengal and Nagpur Railway[1] that the present boring reconnaissance is being made

In the main, this region is a low irregular plateau or upland, the surface of which has a general very easy slope from north to south, with a slight depression or hollow in its southern half, along which the trace of the railway line runs Except at a few points such as where the railway enters on it from the Raigarh or Bilaspur side and leaves it in the Rajpur or Ib river valley, the plateau is edged on all sides, but that to the north-west by a tolerably well-marked escarpment of from 150 to 400 feet in height There are further flat-topped hills in the interior and in the north and eastern portions which attain an elevation of over 1,500 and 1,900 feet above the sea The large village of Hingir is near the centre of the plateau at about 1,200 feet, and the railway trace enters on the western side at 741 feet, runs up to 942 feet in the middle, and leaves, on the Rajpur side, at 790 feet above datum (Karachi, M S L), passing about 4½ miles due south of Hingir The proper plain below the escarpment slopes away gradually, on the south side, towards Sambalpur, on the east, to the Ib and its tributary the Baisandar, but to the south-westward, there is at first only an extremely narrow low-level valley, shut in by a long north-west—south-east ridge of crystalline and transition rocks, outside of which is the proper low country of Raigarh and Bilaspur The drainage system is included between the Kelo tributary of the Mahanadi on the west and the Ib on the east, the plateau itself being mainly watered by the Kur, Oira, and Bagdia nalas on the one side and the Lillari and Dulunga rivers on the south and north-east

The different rock formations are very clearly displayed in the surface features of the country The plateau and escarpment are of sandstones and other beds which Mr Ball classed as 'Upper Sandstones' or 'Hingir Beds,' preferring to leave their position in the Gondwana series rather an open question, his tendency in his latest notice[2] being to range them in "two distinct groups, one containing fossil plants which serve to correlate it with the Kamthi-Raniganj group, the other being probably of Mahadeva age" Beneath these Upper Beds or Kamthis and forming the base of the escarpment, or a low terrace at its foot as well as the low country for some distance out, all round the plateau except to the north-west, are beds of the Barakar formation, with perhaps two or even more coal seams The thickness of the Barakars appears to range from 200 feet at the lowest on the

[1] I am indebted for much of my estimates of thicknesses, &c., of the strata in this region to an Index map and section of the railway surveys The 1 inch map of the Topographical Survey is very poor, full of misplacements of village names, and occasionally out in the courses of the smaller rivers

[2] Manual, Part III, Chap III, p 89.

south-west side of the field, to 600 feet or more on the northern edges Beneath these again lie the Talchirs which crop out at various places in the outer low country.

So far, the definition or display of these three sub-divisions of the lower Gondwanas is perfectly clear, but, as with my former colleague, I am also unable to draw any hard-and-fast line of demarcation between the top of the Barakars and the bottom of the Kamthis At the same time, as far as the present enquiry goes, it will be possible to recognise with approximate accuracy strata of the two formations in such borings as may be made through them

It may seem almost unnecessary to dwell further on any but the Barakar rocks, which, as holding the coal seams, would appear to be those alone requiring search by boring, more particularly as all the rocks have been already described by Mr Ball The exposure of the Barakars is, however, often so very narrow and shut in along the south-western border, and the seams are apparently so near the surface, and thus possibly disconnected by denudation where their area is wider, that the contingency of having to bore through the lower part of the Kamthis must not be overlooked

My further examination of these upper beds shows that they are separable, over most of the field, into three marked bands or zones, the uppermost of which is a set of thick-bedded sandstones, more particularly seen in the higher flat-topped hills of Hingir Beneath these comes a varying thickness of softer and less harsh surfaced strata, with seams and patches of small pebbles and gravel, generally of reddish colours, making up much of that part of the plateau crossed by the railway line Lower still, are more indurated coarse sandstones of red and purple colours, but weathering brown, with which are associated frequent seams and even beds of hard red clays and shales full of characteristic Kamthi species of *Glossopteris*, *Schizoneura*, and *Vertebraria* The thickness of each of these bands varies a good deal, and at times the middle one seems to disappear, while the upper or lower one thickens out

The red-clay zone is fairly persistent throughout, and, as immediately overlying the Barakars, and being occasionally sufficiently denuded to present no insuperable thickness against the boring tool reaching the possibly underlying coal measures, it is of considerable interest Its thickness may be as low as 150 feet along the south-western edge of the plateau, and this may increase to 300 feet on the north-eastern border

The Barakars are, fortunately for purposes of recognition in different parts of the field, also marked by distinguishable bands of strata Their upper portion consists of a decided zone of brown-weathering ironstone flags and thin beds, so characteristic in the south-west fringe of low country as to have been particularly noticed by Mr Ball who, in one part of his report, says "the position of the Barakars is marked by the ironstones" The zone is not very thick here, perhaps hardly 40 feet at the most, and it is constant all down the Sambalpuri-Dibdorah valley as a step or short terrace which widens out at the southern end about Katrapali, Durga, and Singarpur Thus far, it forms a distinct band at the top of the Barakars, but to the eastward, as it rounds into the broader open country of Lakanpur and Rampur, brown flaggy beds occur more distributed through a

greater thickness of these strata which still hold the terraced contour into the Baisandar valley A second and lower band, but of purple and reddish ironstones, also noted by Mr Ball as a "tessalated ironstone," occurs in the lower half of the Barakars, being well displayed in the Rampur country, and again slightly in the Dulunga valley

The upper zone is, however, both stratigraphically and industrially the most important, for it gives a horizon above or below which a great deal can be surmised as to the conditions of the coal-measures themselves, or the series overlying them, while it is from these beds that the principal supply of ore is obtained for the iron furnaces so common over this belt of terraced land

Taking the coal outcrops in order from west to east, the first and indeed the best exposures are in the Oira or Hingir river near Dibdorah, where there are two outcrops which, as the dip is low, may really be parts of one and the same seam At any rate, the upper part of this seam, or the uppermost, if there be two of them, can hardly be so much as 40 feet below the upper ironstones, the interval being of thick-bedded coarse felspathic free-stones The outcrops indicate a good thickness of coal and carbonaceous shale, Mr Ball having cut through 6 feet of coal in one, while I sunk a pit 12 feet deep in the other without reaching the bottom, of which 4 feet was fairly good coal

The next coal was found by Mr Ball in the Bagdia nala near Lakanpur, the top of the seam being alone exposed, it is associated also with thick-bedded sandstones just below the upper ironstone band

Still further east, in the valley of the Lillari river, are some four or five outcrops, the uppermost of which, between the villages of Kalibabahal and Chowdibahal, occurs close up to the ironstone band associated with thinnish beds of grey and buff sandstone The upper part of the seam, of which I ascertained 4 feet 6 inches at least of good coal, is well exposed in the bed of the river Other outcrops occur lower down the river, but it is impossible to say whether they are repetitions of the same seam or parts of this and another. Yet further down the river, near Durlipali, there is a very strong seam, over 40 feet of which was measured by Mr Ball, it underlies the lower ironstone band, with perhaps a small intervening thickness of sandstones

No more coal is known until the north-eastern edge of the field is reached near the deserted village of Dulunga, where, as described by Mr Ball, strong outcrops of coal and shale occur in the river at what I take to be about the same horizon as the Durlipali seam I also found traces of a red and purple subcuboidal concretionary ironstone, answering to the 'tessalated bed,' in close proximity to the coal outcrops, though its position above or below them is not clear Higher up this large nala and about a couple of miles north-west, are traces of carbonaceous shale associated with the upper ironstone band.

Thence northwards, the upper ironstone beds are, as usual, easily followed on the tolerably well-defined terrace below the steep slopes of the lofty Kur and Garjan hills into the Baisandar valley, in the low grounds of which are the further coal outcrops described by Mr Ball These are lying, I believe, in very much the same zones of Barakars as are the other outcrops in the eastern, southern, and south-western edges of the field, though the thickness of the series may be greater

The only remaining consideration is as to the lie or *gisement* of the rocks; and it will easily be understood, from what has been already said of their occurring so uniformly in the plateau and round its edges, that this is very easy or comparatively flat and basonal. The series has, on the whole, a general southerly slope, the lowest beds of the Barakars being at a higher level on the gneiss of the north and north-east sides of the country than they are to the southward and south-west, though the beds rise up towards this latter border and even have a sharp undulation in the escarpment of the Dibdorah valley. This easy lie has also not been interfered with by any decided system of faults,[1] but it can hardly be expected that so large an area shall be devoid of some minor dislocations, of which, however, I have as yet seen no indication.

II.—Division into Boring Areas.

In considering next the problem of selecting the most likely and convenient sites for testing the coal seams by boring, it is necessary to look at the style of the outcrops themselves, their position with regard to the line of railway, and lastly, the possibility of the line itself running over so pierceable a depth of the upper sandstones that seams may even be struck at a convenient depth within immediate reach of it.

In the first place, under these three heads, the whole field can be divided off into sections suitable either for boring or indeed for future colliery works; thus, taking them from west to east:—

I.—*The Kur River Valley*; practically a portion of the line trace, as the railway will enter here on its progress over the plateau from Raigarh.

II.—*The Oira or Hingir River Valley*, in the small Zemindari of Kodibuga, with coal outcrops.

III.—*The Bagdia Valley*, in the western part of Rampur, with a coal outcrop.

IV.—*The Lillari Valley*, in the middle of the Rampur Zemindari, and its upper reaches touching on the line of railway.

V.—*The Dulunga Valley*, on the north east edge of the plateau, in Hingir, with coal outcrops.

VI.—*The Baisandar and Pazar Valleys*, on the north, partly in Hingir and Raigarh, with coal outcrops.

For the first, as being on the railway, I would place it as a favourable section for exploration, but that it has as yet shown no outcrops of coal. It is a convenient place, all three members of the lower Gondwanas are exposed, and there is no escarpment of the upper sandstones in the tract over which the borings would be carried out. My expectation of coal being struck here, at a depth say of 200 feet, is based on the position and strength of the coal outcrops of Dibdorah, a few miles to the south-east. On many considerations, however, it is better to start an exploration of this kind, if possible, from known outcrops such as are exhibited in all the other sections.

[1] The long faulted boundary, suggested by Mr. Ball as occurring on the south west edge of the field, even if it be really a line of dislocation, does not affect the coal measures in any serious way.

The Oira[1] river exhibits, without doubt, the most promising coal exposures, but these lie in an extremely narrow and shut-in valley, the escarpment being here very steep and 175 feet in height, whence it would be very troublesome to deliver the coal to the railway On the other hand, borings might be put down on the plateau within a few miles of the railway, though these would have to be run down perhaps 200 feet before reaching coal

The Bagdia or Lakanpur valley may for the present be left out of consideration, even though it show a coal outcrop It forms an indented bay of low country, shut off to the north from communication with the line of rail by steep slopes of 200 feet in height, there being besides an interval of difficult country in the plateau above The coal outcrop, as far as it shows, is not promising.

The Lillari section, as already stated, is strong in outcrops, none of which are known to contain such a thickness of actual coal as the Dibdoiah exposure This river rises in the plateau some 6 or 7 miles south-south-east of Hingir, and for part of its higher course flows close alongside the railway trace in the neighbourhood of the proposed Hingir Road Station The northernmost or upper outcrop is only about 4 or 5 miles south-south-east of this station, while there is no difficulty of approach, the valley being quite open and without any transverse ridge or escarpment as is the case in the other parts of the field

The Dulunga section lies about the same distance due north of this railway station, but a difficult and hilly country having more or less of an escarpment intervenes The Baisandar and Pazar areas are even more distant and difficult of access

My examination thus leads practically to the conclusion that the Oira and Lillari sections possess on the whole the more favourable conditions for preliminary trial But, when comparing them as to style of outcrop, position with regard to the railway, and the possibility of striking coal at a reasonable depth, there seems little doubt that the latter offers the best combination of these attributes.

(a) —*The Lillari Valley Tract*

The Lillari, from the neighbourhood of the Hingir Road Station to its confluence with the Ib, runs very much in a line at right angles to the rather varying strike of the rocks Thus, in the upper part of its main course, it runs from north-north west to south south-east for 8 miles, when the strata are at first horizontal or nearly so, or with a dip of 5° north-north-west Gradually, this dip may range somewhat higher as lower and lower beds of sandstone, coal, or shale are passed over, though from the fourth of these 8 miles there are strong indications of undulation Then, as the river bends round to the eastward near Ghanamal and Durlipali, the strike of the beds is more south-west—north-east with a rather higher dip never exceeding 10° It is thus no easy matter to estimate the probable thickness of the coal-measures, which really occupy an expanded strip of outcrop fully 5 miles in width. Calculating, however, on the varying dip and the strong indications of rolling in the middle portion, as well as on a comparison

[1] In the 4-inch map t is called the Hingir Nala in its upper reach, and the Jungwus near its confluence with the Mahanadi, but it is also marked Oira in the 1-inch topographical map and the people give it this name

of the exposures here with those to the south-west and north-east, I do not think there can be much more than 400 feet from the top of the brown ironstone band at Chowdibahal to the bottom of the Durlipali seam.

Chowdibahal is only about 4 miles south-west of the Hingir Road Station, being situated on more or less flat beds of the Barakars, which are succeeded, as the river is followed upwards, by the red-clay band of the upper sandstones. The railway station itself will be on the middle sandstones of this series, but they are very thin, since the red-clay band rises up from under them, with a southerly dip, at only about a mile to the north-east near the village of Tangudhi.

The uppermost coal crops out in the river bed about a quarter of a mile below Chowdibahal, and the lowest also shows very strongly in the river close to the village of Durlipali. Thus the Barakars themselves can be tried by boring in two ways: either by testing the seams from below upwards beginning on the sandstones above the Durlipali seam and going north, or by starting at Chowdibahal.

The Durlipali seam is over 40 feet thick, but it is mainly made up of carbonaceous and grey shales with some thin layers of coal, the best of them being only 1′ to 2′, 6″ thick. Of course there may be a great improvement in them to the deep, but this is really all that can be said. I have, however, marked down several sites along the strike, in the sandstones above the seam, in the low hilly country on the left bank of the river, between the villages of Ghanamal (on the right bank), Judiboga (wrongly marked Jamkani on the topographical survey map), and Sumra. Should the borings at those places give good coal, the railway might then be supplied from a distance of 8 or 9 miles; they would, I think, hardly ever run beyond 200 feet, while they ought, on the Judiboga strike, to touch the coal at much lesser depths.

On the other hand, the Kuliabahal-Chowdibahal outcrop gives at least $4\frac{1}{2}$ feet of fairly good coal, which may also go on improving to the deep. The slight dip would fetch the coal, if of fair lateral extent, within easy reach of the Hingir Road Station. Besides, a not unimportant feature bearing on the possible thickness and quality of this seam, or of perhaps another not far below it, must not be lost sight of, namely, that its position just below the ironstone band agrees with that of the Dibdorah and Lakanpur outcrops. It is perhaps scarcely to be hoped that these three widely separated exposures can be parts of one and the same seam; but they certainly appear to be on somewhat the same horizon which so far exhibits coal at other points also round the edge of the field.

A deep boring at this place would at once tell a great deal of the proper coal-bearing capabilities of the Barakars, as well as whether it would be worth while continuing the search here, and it might even touch the lower seam. Preferring, therefore, to depend in the commencement on such a crucial boring as this deep one promises to be, I am induced to advise breaking ground at Chowdibahal; and to this end some twelve sites have been marked in this neighbourhood within an area of about two square miles which can be taken *seriatim* according as the results shall indicate. At the same time, it is quite possible—nay, even probable—that there may be no necessity for carrying this boring to any considerable depth, as the upper seam which ought to be struck within 100 feet may be so promising that the exploration shall remain in it for some time at least.

The accompanying outline map has been prepared from that of the Topographical Survey, hill features being left out, and a few alterations have been introduced from the railway map on the same scale The approximate positions of a few villages, not given in the topographical map, are shown and the names of others corrected Only a few of the boring sites are here laid down.

Note on Lignite *near* Raipur, Central Provinces, *by* PRAMATHA NATH BOSE, B Sc (Lond), F G S, *Geological Survey of India*

The lignite which forms the subject of this note was found in the bed of the Karun[1] river, 3 miles south-west of Ráipur, the capital of the Chhattisghar division of the Central Provinces, within the boundary of the village of Bhátágáon When I visited the place (about the end of April) the water there was about a foot and a half deep The bank of the river on the Bhatágáon side is some 15 feet high, and consists of a light-coloured loam The bed is sandy, and the lignite occurs below the sand as logs in a blackish, rather stiff, alluvial clay, impregnated with peaty matter The logs are black, and show woody structure perfectly well. Their length and thickness are variable, those I obtained had a maximum diameter of six inches During the rains when a strong current has removed the overlying sand, these logs are, I was told, well exposed They are then taken out by the people of Bhátágaon, stealthily it seems, for, though the villagers must have removed many cart-loads of the substance within the last ten or twelve years, and though its utility as fuel in a treeless country like Ráipur is beyond question, not a breath had reached the official ear, and Bhátágáon is only a quarter of an hour's ride from Ráipur

From the amount reported to have been extracted by the people of Bhátágáon, and from the facility with which log after log was thrown up in my presence, I was satisfied that the lignite occurs in some quantity at the place I cannot be very sanguine, however, considering that the alluvial deposits in which it occurs are confined to the immediate vicinity of the river and are not likely to be more than 30 feet in thickness (from the surface), if even so much, the Vindhyan limestone cropping out in all directions except the south, even in the bed of the river almost within sight of the place where the lignite occurs On the other hand, I was informed that lignite had been found two years ago in the bed of a streamlet which marks off the boundary of the village of Khurmurá from that of Ghugwá, close to its junction with the Karun. I went to the spot The water here was no deeper than at Bhátágáon, but my search was fruitless From the evidence before me, however, I saw no reason to impugn the veracity of my informants I also heard of a similar find at Jumráo, two miles and a half south of the spot where lignite was dug out at Bhátágáon If this statement stands verification, and I think it will, the extent of the lignite would be by no means inconsiderable

Owing to the presence of water I could not get at any exposure which would enable one to come to any conclusions worth recording about the origin of the

[1] Spelt "Karoon" in the Revenue Survey Map The river is also known as "Kumeri"

lignite, its exact mode of occurrence, and other allied questions. The specimens of lignite I got all belong to Dicotyledonous land plants, of which the jungles enclosing the plain of Chhattisghar are still almost exclusively made up. In the peaty matter associated with the lignite mentioned before were some leaves fairly enough preserved for identification. Unfortunately, those I brought away have been hopelessly crushed. When more specimens are obtained, exact specific determination would be an easy task.

The following are the results of the analyses of two specimens made by Mr. Hira Lal, of the Geological Survey:—

	No. 1	No. 2.
Moisture	21·76	11·64
Volatile matter (exclusive of moisture)	44·84	52·36
Fixed carbon	28·30	30·00
Ash	5·10	6·00
	100·00	100·00

The excessive moisture in specimen No. 1 is probably accounted for by the fact that it was exposed to the atmosphere of the laboratory for 48 hours after it had been dried in a water bath. No. 2 was not so dried, but was sufficiently dry for analysis. The lignite was found to cake, and the ash is brownish.

The results indicate a fuel certainly poorer than coal. But the proportion of fixed carbon is higher than in ordinary peat, and the heating power consequently greater. Its economic importance cannot be exaggerated. For some 30 miles round Ráipur there is not a bit of jungle to be seen anywhere. Wood is consequently extremely dear.[1] A cheaper substitute, such as the lignite promises to be, would be highly welcome.

I came to know about the lignite in the fag end of the last season, after I had packed and stored my tents away, and made all arrangements for leaving Ráipur.[2] Next season I propose to resume work there, and have a closer search. I would recommend diggings on a small scale at Bhatágáon, Ghugwá, and Jumráo. The co-operation of an engineer will probably be required. But I have no doubt the enlightened officers of the district will cordially help in the matter.

Besides the economical importance of the subject, the scientific interest attaching to it is very great. The whole district of Ráipur has been land ever since the Vindhyan period. For ages past, therefore, it must have supported vegetable and animal life to a greater or lesser extent. But the conditions for the safe preservation of terrestrial life are so very hard, that one might hunt the whole country from one end of it to the other, without coming upon any but the barest remains belonging to the animals or the plants, which, geologically speaking, lived but yesterday. Any localities, therefore, which, like Bhátágáon, promise us materials, however scanty, for the history of the terrestrial fauna and flora, should be thoroughly and carefully searched, especially as the life-history of the entire district is a great blank, the Vindhyan sandstones and limestones having nowhere yielded a trace of a fossil yet.

[1] Firewood sells at Ráipur at 10 to 12 annas per maund.

[2] I am indebted for the information to Messrs. J. N. Sircar, Barrister at law, and D. Sinclair, proprietor of Bhátágáon.

The Turquoise Mines *of* Nishâpûr, Khorassan,[1] *by* A. HOUTUM SCHINDLER, *General, Persian Service.*

Geographical.—The mines known as the "Nishâpûr Turquoise Mines" are situated in the Bâr-i-Madèn, a district of the Nishâpûr province, about 40 miles north-east of Sabzvâr, and 32 miles north-west of Nishâpûr. The principal place of the Bâr-i-Madèn district is the village Madèn, which consist of two villages, the Kale-i-bâlâ and the Kale-i-pain, with a population of about 1,200 souls. The Kale-i-bâlâ lies 5,100 feet above the level of the sea in latitude 36° 28′ 11″ north, and longitude 58° 20′ west of Greenwich. A few smaller villages, there called "kelâtehs," belong to the Madèn village, and contain about 300 inhabitants. The total population of the Madèn villages was on 1st July, 1882, 1,501. Twelve other large and several smaller villages belong to the Bâr-i-Madèn district; of these it is, however, not necessary to speak any further. The Maden village and the territory belonging to it cover about 40 square miles of ground. Most of this is situated in a wide open valley, which, as it has no particular name, I shall call the Madèn valley. This valley, running in an east-west direction, is bounded on the north by the turquoise mountains, and on the south by the Batau mountains; on the east are some low hills separating it from the Nishâpûr plain, on the west the ground falls gently towards the Jowein plain. The thalweg of the Madèn valley is formed by the Kâl-i-Mansûrah (Kâl means river in Khorassan, or rather a river-bed), which rarely has any water, and flows nearly due west towards the Jowein plain; it reaches the Jowein plain after receiving several streams from the north, flows through the plain, and then curves southwards,

[1] Communicated, from the Foreign Department, through the Revenue and Agricultural Department, Government of India.

So little definite information concerning the occurrence of the Turquoise has hitherto been available that the above paper, even though it has but an indirect association with Indian geology, comes as a very welcome contribution to the history of precious stones. All authorities on this study give this very locality as being almost the only one whence the stone has been procured in its most perfect condition of colour; but Silesia, Oelsnitz in Saxony, and the valley of the Galasteo, south east of Santa Fè in Europe, Thibet, and China, are given by various writers as producing stones of inferior quality. A form of very fine but not lasting colour is also found near Mount Sinai in Arabia Petræa.

In the Manual of the Geology of India, Part III, there is the following notice: "The hydrous aluminum phosphate, or calaite, otherwise known as Turquoise, may be mentioned here, though its occurrence in India is doubtful. Mr. Prinsep (Journ. As. Soc. Bengal, Vol. IV, p. 584), from the presence of certain blue streaks in the copper ores of Rajauri in Ajmir, suggested the possibility of turquoise being found there. Subsequently Dr. Irvine (Topography of Ajmir, p. 162) stated that it was reported to be found in the Ajmir hills and at Ramgarh in the Shakhwati country and was used for rings, but it seems possible that this was really a variety of blue copper which Prinsep called a turquoise copper ore. There has been no recent recorded discovery of turquoise in this region."

"The principle known turquoise mines in the world are at Ausar, near Nisâhpûr in Khorassan in Persia, to which Tavernier alluded under the name of Michebourg."

By the way, the latter name is here possibly a misprint, for Tavernier's account is thus given in Dieulafait's "*Diamonds and Precious Stones*," p. 141. "The mine of turquoise which furnishes the most beautiful stones is three days' journey from Meshed, turning to the north-west after passing the large town of Nishabourg."

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cutting the highroad between Shâhrûd and Meshed a little east of Abbâsâbâd. It is there passed by the Pul-i-Abrishun (Bridge of Silk), famous in former years for the Turkomans, who there, or in its immediate vicinity, attacked more caravans than anywhere else on the Meshed road

Geological—The mountains of the district consist of nummulitic limestones and sandstones lying on clay-slates, and inclosing immense beds of gypsum and rock-salt The slates rise in the Batau mountain, whose peaks they form, to the absolute height of 6,400 feet, 1,860 feet above the thalweg of the Madèn valley The limestones rise in the Si-sar peak, 3 miles east of the Kále-i-balâ, to an absolute height of 5,900 feet The stratified rocks are, on the north of the valley, broken through by porphyries and greenstones, and in consequence greatly metamorphosed, and the turquoise bearing ridge consists entirely of porphyries, greenstones, and metamorphosed limestones and sandstones This ridge rises to an absolute height of 6,655 feet The turquoises form veins in the metamorphosed strata, which have partly lost their original stratification, and contain minute pieces of free silica The general direction of the turquoise veins is N 70° E—S 70° W, the same as that of the strike of the stratified rocks The highest spot at which turquoises have been found lies 5,800 feet above the level of the sea, the lowest spot 4,800 feet

Climate—The climate is very salubrious The greatest heat does not exceed 82° to 83° F, the greatest cold is very seldom 40° F below freezing point The winter of 1882-83 was exceptionally cold at the mines, the same as all over the north of Persia Wheat and barley, and mulberry-trees grow well at an absolute height of 5,000 to 5,300 feet Asafœtida and fig-trees, the latter bearing no fruit, grow on the mountain slopes to a height of 6,000 feet The rainfall slightly exceeds that of the greater part of Khorassan A strong north wind blows almost continually, and keeps the air very pure Some years ago, when most of the villages of the district were ravaged by the plague, and two years ago, when there was an epidemic of diphtheria in the neighbourhood, the Madèn village remained free of sickness

Inhabitants and produce—The inhabitants of the Maden village are entirely occupied with the obtaining, cutting, and selling of turquoises Agriculture is there very much neglected Water is not plentiful, but certainly enough for the sowing of 100 to 150 kharvars of grain, as it is, only 10 to 15 kharvars are sown, and the harvest hardly ever produces more than 100 kharvars The villages in the immediate neighbourhood with the same kind of ground and soil, and almost the same climate, have many "deimî" fields (fields watered by rain only), the Madèn village has none Some families occupy themselves with the rearing of silkworms, and produce about 120 lbs of silk per annum Poppy had been sown in a garden in 1881, but was found to contain very little opium, and the people have since then abstained from poppy cultivation Nearly all the male inhabitants of the Maden village are inveterate opium smokers, and many women have also acquired that vice The gain of turquoises has made the people careless of anything else, there are, however, very few of the inhabitants who possess anything worth speaking of A good turquoise is found, and the money obtained by its sale is spent at once, one can often see at the mines men who yearly pay 60

tomans to the Government, and who gain quite 150 tomans besides, having nothing to eat

Mines of the district—The mines belonging to the Madèn village are (1) the turquoise mines, (2) a salt mine, (3) a lead mine, (4) a millstone quarry

I shall speak separately of each

1 *Turquoise mines*—The turquoise mines are of two kinds (*a*) the mines proper, shafts and galleries in the rocks, and (*b*) the Khâkî mines, diggings in the detritus of disintegrated rocks washed down towards the plain

(*a*) The mines proper

The most easterly, and according to all accounts the oldest mine is the Abdurrezzâgî, which was formerly called the Abû Ishâgî, and is with that name mentioned in old books Its mouth is at the absolute height of 5,900 feet, it is a very extensive mine and has a depth of about 160 feet vertical from its mouth For the last few years very few turquoises have been obtained from this mine, but its turquoises are esteemed more than those of other mines Close to this mine, and in the same valley, are the Surkh, Shâperdâr and Aghâlî mines, which are at present neglected A little to the west of the Abdurrezzâgi valley is the "Derreh-i-Safîd," the white valley, with the old mines Mâlekî, the upper and lower Zâkî and the Mîrzâ Ahmedî The former three are immense mines, but almost entirely filled up In the lower Zâkî, now a vertical shaft of 60 feet in depth, and about 250 feet in circumference, one can plainly see how the mines have got to their present ruined state It is apparent that the mines were formerly well directed Vertical shafts were cut into the rock for lighting and ventilating the mine, while the entrance of the mine was by lateral galleries driven in on the slopes of the mountains I think it very probable that the mines were, as late as the first quarter of the last century, worked by the Government The mines were then, when the Sefâvîeh dynasty came to an end, neglected and left to the people of the village, or perhaps, as now, farmed to them The farmers thought only of getting a quick return for their money and cut away the rock wherever they saw any turquoises, exactly as they do at the present day The result was that the supporting pillars and the rock between the different shafts were cut away, and that the roof, so to say, of the whole mine, fell down, filling it up The three above-mentioned mines have been filled up like this One can form an estimate of the original depth of the Zâkî mine from its present depth, which is only to the surface of the, formerly, superincumbent roof, and from a shaft or burrow dug into the rubbish of the old mine This burrow begins where the fallen-down roof begins, at a depth of 60 feet from the mouth of the mine and goes down about another 60 feet vertical At the end of this burrow, 120 feet below the mouth of the mine, there are still no signs of the original old mine Several attempts have been made to clear this mine, but no one up to now has had either the will to provide the necessary funds or the patience to wait for the completion of the work The turquoises of the "white valley" are also very good, not so good, however, as those of the Abdurrezzâgî Many turquoises, generally small, are found in the rubbish of the old mines, they are much prized for their good colour. The mouth of the Mirza Ahmedî mine, which was probably once a part of the Zâkî mines, lies about 80 feet lower than that of the Zâkî

mine, and goes down 80 feet vertical It also has very good turquoises, but working in it is very precarious on account of the bad state of the galleries and the amount of loose rubbish they contain

The next valley is the Derreh-i-Dar-i-Kûh In it are several important mines, the Kerbelâi Kerîmî, the Dar-i-Kûh, and others. The Dar-i-Kûh mine is very deep, going down about 150 feet vertical It is an old and very extensive mine, and some of its galleries continue as far as the Zâkî mine, it is very dangerous on account of the rubbish it contains, the rubbish is badly propped up by stones and small sticks, and several labourers have at times been buried in it One of its galleries called the Dânekî goes for about 100 feet through rubbish, the width of this gallery is 1 to 2 feet, its height not more, and the descent down it is very dangerous Only three or four of the miners have the courage to go into this gallery Some galleries of this mine are completely filled up, and can only be cleared at great expense and with difficulty Above the mine can be seen many shafts which formerly lighted and ventilated the mine, but are now filled up All the mines in the Dar-i-Kûh valley are worked and contain good turquoises

Further west is the "Derreh-i-Sîyah," the black valley with the old Ali Mirzai (a contraction of Ali Murtezâ) and the Reîsh mines The Ali Mirzâî, particularly the lower one of that name, is very dangerous The rock is very soft and much disintegrated, often falls and fills up the mine A part of this mine is called the "Bî-râh-rô," the shaft "without a road", to go down into it is very difficult The turquoises of the Ali Mirzâi are not very good, their colour soon fades

On the top of the Reîsh mine, in the same valley, a vein of turquoises was discovered a year or two ago, and a new mine was opened there with the name of "Sar-i-Reish" (the head of the Reîsh) In it are found turquoises of fine colour and of great size, but the colour soon fades and the turquoise becomes a dirty green with white and grey spots As long as these turquoises are kept damp they preserve their colour, if once they get dry they are worth very little A turquoise as large as a walnut and of a fine colour was found in this mine last year, it was, against my advice, or rather I was not asked, presented to His Majesty the Shah, after it had been two days with His Majesty it became green and whitish, and was found to be worth nothing

The next valley called the "Derreh-i-Sabz," the green valley, contains the old Ardelânî and Sabz mines and the new Anjîri mines The Ardelânî was once a very great mine, more than twelve old shafts, now all filled up, are still to be seen, its present entrance is by a large artificial cave with a dome-like roof, it has a vertical depth of 85 feet and is very badly ventilated, having several galleries with foul air Such galleries are called "chirâgh-kush," i e, lamp extinguishers The Ardelânî turquoises are not good A "Jowâher nâmeh" (book on jewels), written during the seventeenth century, mentions that the turquoises of the most inferior quality were obtained from the Ardelânî

The Sabz mine has, as its name implies, green turquoises and is at present filled up The Anjîrî mines, which have their name from some fig-trees growing in the valley (Anjîr=fig), are new mines They produced during the last few years a very great quantity of turquoises which had a fine colour and were sold

well The colour of those turquoises, however, soon faded, and the possessors of these turquoises are now far from satisfied with their purchases I believe that the great fall in the price of turquoises in Europe is mainly due to the many stones of these, as well of the Sar-i-Reîsh mines These stones were sent to Europe and kept moist in earthenware pots till they were sold Out of the damp they lost colour, and in a year or two they became quite white European jewellers have at present no confidence in turquoises, and buy only at very low prices

The next and last, also the most westerly valley, is the one with the Kemerí mine This mine is full of water at present, and the several attempts made to empty it have failed, it has some thick veins of turquoises, but the stones are of no use for rings, being generally worked into amulets, brooches, seals, &c

A little to the south of the Ali Mirzâi mine lies the Khurûj mine, very extensive, but partly filled up, it had, some sixty years ago, very good turquoises, and is at present not worked There are many more mines with names, perhaps a hundred, and more than a hundred nameless ones, but they are either parts of those I have enumerated, or unimportant Work in these mines is carried on by means of picks and crowbars, and gunpowder Blasting with gunpowder has come in vogue only within the last thirty years, formerly all the work was done by picks, and much better the picks extracted the turquoises entire, the gunpowder does more work, but breaks the stones into small pieces

(*b*) The Khâkî mines are diggings in the detritus and rubbish collected at the foot of the above-mentioned mines, and in the alluvial soil, consisting of the detritus of the rocks, and extending from the foot of the mountain a mile or two down to the plain The finest turquoises are at present found in the Khâkî mines,—in fact, good ringstones are at present obtained only from the Khâkî Work here is carried on by promiscuous diggings, without any system whatever The earth is brought to the surface, sifted, and searched for turquoises, the latter work is generally done by children The fine turquoise presented by the Gavan-ed-Dowleh to the Shah, valued at 2,000*l*, as well as many other fine ones, were found in the Khâkî

2 *The salt mine* —The salt mine is situated about 6 miles east of the Madèn village, near the little hamlet Garaghûchî The salt consists of an immense bed of rock salt inclosed by gypsum and nummulitic limestone The salt is very white and clear, in many parts quite as transparent as glass I have seen documents relating to this mine dated 1780

3 *Lead mine* —The lead mine lies about 6 miles south of the Madèn village in the Batau mountain (which has its name from the village Batau, lying on its southern slopes, in the Tâghûn Kûh district) The lead occurs in irregular veins, striking N 40° E —S 40° W, in slates underlying limestones The mine is not an important one, and has not been worked for many years,—in fact, not since the accession of the present Shah As soon as the news of Muhammed Shah's demise reached Khorassan, the Amarlû Kurds revolted, and took possession of the turquoise mines The inhabitants of the Madèn village fled to the Batau mountain, and worked the lead mine for a few months, till order was restored, and the Kurds left the turquoise mines The mine has since then been neglected

Millstone quarry—The millstone quarry lies about 4 miles south of the Madèn village, on the northern slope of the Batau mountain. The stones are cut out of a rough sandstone, or quartzose grit, lying under the sandstone of the nummulitic formation About twenty or thirty pairs of stones are obtained per annum and sold at 6 tomans a pair

Revenue and arrangement of rent—The Persian Government received up to 21st March, 1882, on account of these four mines, the sum of 8,000 tomans per annum Either the inhabitants of the Madèn village paid this sum themselves, and worked the mines at their own risk, or some person farmed the mines from the Government for the same sum, retained one or two mines for his exclusive benefit, worked one or two others in partnership with some of the villagers, and sublet the remainder for 5,000 or 6,000 tomans per annum to the villagers The villagers generally paid what had been agreed upon in turquoises, and they could sell the turquoises they obtained how and where they liked The money which they had to pay was divided at the rate of 60 tomans "a head" among the rayots, some rayots, according to their means, number of children, &c, paying a whole head, others seven-eighths, three-fourths, &c, to one-quarter of a head, or 15 tomans a year The Kedkhodas, of which there were five, paid nothing, and fixed the amount each rayot had to pay Some Syeds, two or three Mullas, the barbers, and some of the relatives or friends of the Kedkhodas were also exempted The barbers of the district possess Firmans of the Sefâvîeh monarchs, exempting them from taxes in perpetuity I saw Firmans of Shah Tâmâsp dated A H 1038, of Shah Abbâs dated 1062, and of Shah Sultan Hussein dated 1091

The salt mine was given to the Syeds of the village, in lieu of 250 tomans pension during Kerîm Khân's reign, the Syeds later sold their right to the salt mine for about 2,000 tomans to some of the villagers, who since then call the mine their private property In the Government accounts, however, the mine still figures as Crown property, at a yearly rent of 250 tomans, and this sum is included in the 8,000 tomans which the Government receives from the turquoise mine and its villages From the 21st March, 1882, His Majesty the Shah gave the turquoise mines, and the thereto-belonging district, to the Mukhber-ed-Dowleh for a period of fifteen years, and the Mukhber-ed-Dowleh agreed to pay 9,000 tomans the first year, and 18,000 tomans for the remaining fourteen years

Classification of turquoises—The turquoises are at the mines first divided in three classes or kinds (1) Angushtarî, (2) Bârkhâneh, (3) Arabî

1 All turquoises of good and "fast" colour and favourable shape are classed with the Angushtarî stones (ring stones) They are sold by the piece It is impossible to fix any price or classify them according to different qualities I have not yet seen two stones alike A stone two-thirds of an inch in length, two-fifths of an inch in width, and about half an inch in thickness, cut "peikânî" shape, was valued at Meshed 300*l*, another of about the same size, shape, and cut was valued at only 80*l* Turquoises of the size of a pea are sometimes sold for 8*l* The colour prized most is the deep blue of the sky A small speck of a lighter colour, which only connoisseurs can distinguish, or an almost unappreciable tinge of green, decreases the value considerably Then there is that undefinable property of a good turquoise the "zât," something like the "water" of

a diamond or the lustre of a pearl, a fine coloured turquoise without the "zât" is not worth much A deep colour, almost an indigo-like blue, is called "talkh" bitter, and decreases the value of the stone The best Angushtarî stones are found in the Khâki diggings, and in the Abdurrezzâgî mine

2 The bârkhâneh stones are generally divided into four qualities and are sold by weight The first quality costs at the mines 1,500 to 1,600 tomans per Tabrîz mann, equal to about 90*l* per lb The fourth quality is worth 70 to 80 tomans per mann Only the first and part of the second quality are sent to Europe, the others are sold in the country to Persian jewellers and goldsmiths, particularly at Meshed, and are employed for encrusting Persian articles of jewellery, amulets, dagger and sword hilts and sheaths, horse trappings, pipeheads, &c One can at Meshed buy small cut turquoises of the third quality at the rate of 2*s* to 3*s* per 1,000 Many of the bârkhâneh turquoises sent to Europe are employed by the European jewellers for rings, but the mere fact of the miners themselves not classing them with the Angushtarî stones proves that they are not of the first quality

3 *Arabî turquoises*—All stones not belonging to the first two kinds are called Arabî Their name is of recent origin, and was first adopted by the people at the mines for bad and in Persia unsaleable stones Some of the miners when on a pilgrimage to Mekka had taken with them a quantity of bad turquoises and had sold them well to the Arabs Since then any pale-coloured or greenish and spotted turquoise is called Arabî The whitish turquoises of this kind are called shîrbûmî, or shîrfâm, and round pieces with a white crust are called chaghâleh Many of the so-called Arabî turquoises are, however, bought by Persians, and some also go to Europe The large flat pieces and slabs used for amulets, brooches, belt buckles, &c, at the mines called tûfâl, are now classed with the Arabî stones, although some of them are very much esteemed pieces of 2 inches in length, 1 in width, and ⅛ in thickness, being sometimes valued at 10 tomans Stones of a greenish colour, called Gul-i-Kâsnî (chicory) are bought principally by Afghans I have seen about 12 lbs in weight of pale-coloured, uncut, tûfâl stones, sold at the mines for 180 tomans

Sale of turquoises—About 200 men of the village work in the mines and in the Khâkî diggings, and twenty-five or thirty, the Rîsh-i-Safîds, Elders of the village, buy the turquoises and sell them to merchants and jewellers, either at Meshed or at the mines The original finders of the turquoises do not gain much, a man who works in the mines gains on an average 5 krans per diem in turquoises Work in the mines is difficult, but sure, a miner never returns empty-handed In the diggings the work is comparatively easy, but the finding of a turquoise is a matter of chance It often happens that a miner, after working hard for a few months in the mines, and having saved a few tomans, tries his chance at the diggings, works there finding nothing till his money is finished, sells and pawns his goods and chattels, still finds nothing, and finally, to keep starvation out of the doors, has to return to the mines Good workmen never go to the Khâkî diggings, but send their children there Of the 200 miners at the village, quite 130 work in the mines, the old and the weak, or those who possess a little property and are in no want of a certain daily gain, and the lazy, work in the Khâkî During the summer months many strangers come to the mines

and try their chance at the diggings The Rîsh-i-Safîds generally buy the turquoises direct from the workmen, and then sell them to the merchants at Meshed or to "dellâls" (commission agents) who visit the mines The first profit on all turquoises is never less than 10 per cent, generally amounts to 20 per cent That is, one of the Rîsh-i-Safîds buys turquoises for 10 tomans from a miner or from different miners and sells them to a "dellâl" for 12 tomans The "dellâl" goes to Meshed and sells them to the dealers for 14 or 15 tomans The dealer sorts them, sells some of them in the country and sends the remainder to Europe, generally to Moscow, where they are sold by special "dellâls" to the European dealers It may be calculated that turquoises bought for 10 tomans at the mines are sold for 25 tomans in Europe It is strange that European dealers have up to now not thought it worth their while to send their own agents to the mines

The miners themselves rarely cut their turquoises, and they therefore seldom know if they have found any good stones or not The Rîsh-i-Safîd, who is the first buyer, however, often half cuts the turquoises, and is then enabled to sort them The Angushtarî turquoises are then put aside and sold singly, and enormous profits are often made

The above-mentioned 300*l* Meshed turquoise was bought from the finder by one of the Rîsh-i-Safîds for 3*l*, the latter sold it still uncut at Meshed for 38*l* As soon as it was cut, its true value became apparent, and it was sent to Paris, where it was valued at 600*l* The second purchaser, however, received only 340*l* for it, the difference was gained by the agents

The annual output of the mines, mountains, and diggings, averaged for the last few years 25,000 tomans' worth of turquoises, valued at the mines The final purchasers probably pay three times this amount

Cutting turquoises, &c—The turquoises are now generally cut by wheels made of a composition of emery and gum The emery is brought from Badakhshan, the gum from India. The cutter drives the wheel with his right hand by means of a stick and a piece of string, which latter is twisted round the axle of the wheel, he holds the stone with his left hand against the wheel, the thumb and one finger holding the stone being protected by rags, leather, or flat pieces of wood Wheels have not been in use long, perhaps only thirty years Formerly all turquoises were cut on slabs of sandstone The turquoise was held by a slit in a piece of wood, and was rapidly rubbed up and down the stone Even now many stones are cut in this manner Very small stones are seldom ever cut on the wheel, but always on the sandstone After the turquoises have been cut, they are polished by being rubbed, first on a slab of very fine grained sandstone ("masgal"), and then on a piece of soft leather with turquoise dust which has been collected from the wheels This polishing process is called "jelâ dâdan"

The pay of a turquoise cutter at the mines or at Meshed is 1 to 2 krans per diem, the cutter providing wheel and other necessaries A cutter on stone receives never more than 1 kran per diem The final polishing is generally done by children, who receive one-third to one-half kran per diem One man can cut a handful of turquoises a day, one polisher suffices for three cutters Turquoises are cut in various shapes The shape depends on the size and original shape of the stone, as well as on its quality The two principal shapes are the "peikani"

and the "mussatah,"—that is, the conical and the flat The less the cone is truncated, the more the turquoise is prized, and again a conical turquoise with an elliptical base is worth more than one with a circular base Turquoises not possessing sufficient thickness for the "peikânî" cut, and being thicker than necessary for the flat cut, are cut *en cabochon*, and the higher the convex surface the more the value of the turquoise Only very fine and deep-coloured turquoises are cut in the "peikânî" shape, the apex of a bad and pale-coloured turquoise would, if cut "peikânî" shape, appear almost white The slabs of the Arabî quality are generally cut plane, seldom with a convex surface Smaller stones are employed for seals, larger stones for amulets, &c The larger stones are never free of flaws, and seldom have a good colour, but the jewellers very cleverly hide the flaws with a scroll-work of gold, or if there be any characters engraved on the stone, they manage to place the letters, and particularly the diacritical points, just over the flaws I have seen sold at the mines a slab 2 inches in length for 25 krans, it had in parts a very beautiful colour, but the greater part of it was full of black spots and veins This slab was worked up by a jeweller at Meshed, with a verse of the Gorân and some scroll-work, and sold for 60 tomans, all the spots and veins had disappeared

Historical note—Some of the inhabitants of the Madèn village say that their ancestors were Jews, others say that their ancestors came originally from Badakhshân, where they were ruby-cutters Many of the inhabitants are Syeds of the family of the fifth Imâm, and one of the sons of that Imâm lies buried at the village Germâb, a few miles north-west of the mines In a genealogical tree of one of these Syeds, written in the fourteenth century, I noticed that the name of the Madèn village was formerly Pashân, changed later on into Fishan The turquoise mines are rarely mentioned in Persian histories

Salt—The north eastern part of Khorassan has three important salt mines the mine near Sherîfâbâd, 24 miles south of Meshed, that of Abjû, 15 miles from Nishâpûr, and that of the turquoise mines Meshed and its environs, and the village as far as Gadamgâh, about 16 miles to the south-east of Nishâpûr, take their salt from the first mine Nishâpûr and its villages are provided from the second, and all the country to the north as far as Kûchân and even Askâbâd take their salt from the last mine, the one belonging to the turquoise mine village This last mine has thus the greatest sale It sells, at a low estimate, 15,000 loads at 150*l* to 180*l* each per annum, or a total quantity of about 1,100 tons The salt is sold at the mine at the rate of 1 kran per donkey-load, which is equal to about 13 krans, say about 9*s* per ton The expenditure of obtaining this quantity hardly amounts to 120*l* per annum, the salt mine, therefore, had been worked by the people who held it at a rent of 250 tomans per annum at an enormous profit The rent was therefore increased to 600 tomans last year, and to 1,000 tomans this year

The work at the mines, 1882-83—I have mentioned that the Mukhber-ed-Dowleh obtained from His Majesty the Shah the concession of the turquoise mines for fifteen years, to begin from the 21st March 1882 The Shah was to receive 9,000 tomans for the first, and 18,000 tomans for each of the remaining fourteen years The Mukhber-ed-Dowleh took in partnership Amîn ed-Dowleh, Nassîr-ed-Dowleh, and two Tehran merchants, Hajjî Ali Nagî and Abdulbâgî,

and agreed to about three-fifths of the responsibilities, the other two-fifths being divided between the four other partners. I was sent to the mines in April 1882 as Director of the mines and Governor of the thereto-belonging district. I had orders to work all the mines, mountains and Khâkî, and monopolize the whole turquoise trade for the Company, by sending all turquoises to Tehran. I had full authority to act as I considered best for the profit of the Company regarding the working of the mines, increasing or abolishing taxes, &c. I arrived at the mines in May, and had after a fortnight organized an administration, arranged the proper working of the mines, and abolished the promiscuous sale and purchase of the turquoises by the rayots. As I worked all the mines for the benefit of the Company the rayots could in justice not be expected to pay any tax on the mines, and I reduced the 8,000 tomans they paid when in possession of all the mines to 500 tomans, which I calculated on their sheep, cattle, fields, &c. The rayots were very much satisfied with this arrangement, but difficulties soon arose. The partners, instead of letting me do as I considered best, and as really was best for them, interfered continually. Every day I received different orders; the Rîsh-i-Safîds, who under the new régime found themselves deprived of the gains they formerly had when they could buy turquoises from the mines and sell them at Meshed, intrigued; the partners of the Company neglected to supply me with money, and once when I had kept the miners seven weeks without their wages there was a strike; the villagers revolted, &c. In spite of all these difficulties I worked the mines, if not at a profit, certainly not at a loss, and left them in May of this year.

The work in 1883.—The partners then arranged to take again a tax from the villagers, 8,000 tomans instead of 5,000 as before, work a few mines themselves, and let others separately to some of the Rish-i-Safids and villagers. They also continue to monopolize the turquoise trade and prohibit the selling of the turquoises by the rayots to others but their agents. They have wisely discontinued the dispatch of all turquoises to Tehran as well as the cutting of them at Tehran. They now keep only the good turquoises and sell the inferior qualities at the mines or at Meshed. The mines may with these arrangements be worked without a loss, but the profit, if there is any, is, as can be seen from the following estimate of income and expenditure, very small:—

INCOME.

Present income and expenditure.

	Tomans.[1]
Taxes on turquoise mines .	8,000
„ salt mine	1,000
(These two sums are generally paid in turquoises.)	
Value of turquoises obtained from the three or four mines kept by the Company	6,000
Profit on sale of turquoises bought from the rayots, and received in lieu of taxes, 10,000 tomans bought and 9,000 tomans taxes	5,000
Total income	20,000

[1] The present value of the toman is 6s. 8d.—Foreign Office, January 1884.

The two last items, 6,000 and 5,000 tomans, are maxima, whenever they do not reach those figures, which is very probable, there will be a loss

EXPENDITURE

	Tomans.
Yearly rent to Government	18,000
Administration expenses	1,500
Working expenses and wages, &c, of the mines kept by the Company	500
Total expenditure	20,000

Tehran, October 6th, 1883

Notice *of a further* Fiery Eruption *from the* Minbyin Mud Volcano *of* Cheduba Island, Arakan

From COLONEL E B SLADEN, M S C., *Commissioner of Arakán, to the Superintendent, Geological Survey of India, dated Akyab, the 27th May 1884*.

I have the honour to annex for your information translation of a report by the Myoôk of Cheduba Island Township, in the Kyouk Pyu District of this Division, relative to a volcanic eruption which is said to have taken place on the island on the morning of the 28th ultimo This is the same volcano which was in activity on the 31st December 1881, as reported in my letter under date the 4th January 1882 [1]

Report of Mra Tha Dun, *Myoôk of Cheduba Township, Kyouk Pyu District*

The Myook of Cheduba respectfully begs to report that about 8 o'clock on the morning of the 28th April last the volcano in the Minbyin Circle of this Township was observed to be in eruption The report of the eruption was brought to me by the Yazawootgoung of the place Appended are the questions put him and his replies thereto —

Question	*Answer*
1 Did the eruption burst out violently or was it gradual?	Sudden and violent
2 To what height did the flames rise?	Apparently about 2,400 feet (*sic*)
3 What was the circumference?	About 600 feet
4 How long did the eruption last?	About an hour
5 Did the flames give out any smell?	A smell of petroleum
6 Was there much smoke?	Yes, dense smoke
7 Was mud ejected?	Mud and gravel

[1] See Records, Geological Survey of India, Volume XV, page 141

Report on the Langrin Coal Field, South-West Khasia Hills, *by* TOM D LA TOUCHE, B A , *Geological Survey of India* (With a map)

On my return from the Aka expedition in the beginning of February last, I made arrangements to visit and examine in detail the coal field situated in the Khasia Hills to the north of Langrin in Sylhet, one section in which, namely, that near Borsora, I had visited in May 1883, and described in Vol XVI, Part 3 of the Records for that year In that report I drew attention to the similarity between that section and the one described by Colonel Godwin-Austen as occurring on the Um Plu, a tributary of the Um Blay, about 10 miles to the north-west of Borsora (J A S B, Vol XXXVIII, Part II, No 1, 1869), and the object I had in view was to find out whether the coal-bearing rocks were continuous in the intermediate area, and to search for other sections of the coal seams Owing to the difficulty of procuring coolies, and my having to march across the hills from Gauhati, I did not reach the coal field till the last week in February, and so was not able to do as much as I had intended, but, as far as they go, the result of my investigations has been satisfactory The coal-bearing rocks are exposed over an area of nearly 30 square miles, and at several points in this area, I have found exposures of coal at about the same horizon as that of the above-mentioned sections, so that there can, I think, be little doubt that there is a large amount of coal available here within a short distance of the plains

The area examined is a plateau roughly triangular in shape, bounded on the north-east by a steep scarp overlooking the river Um Blay, on the south by the plains of Sylhet, and on the west by a range of hills of newer formation than the coal-bearing rocks The average elevation of this plateau is about 1,500 feet above the plains, its surface sloping gradually (at an angle of 5° to 7°) to the south-west, and descending abruptly on the south to the plains. It is deeply trenched by several small streams, the two principal being the Um Plu flowing north-east into the Um Blay, and the Um Soor flowing south into the plains Both of these have cut far back into the plateau, and flow in narrow gorges several hundred feet deep Numerous smaller streams flow into the plains, the principal drainage being in this direction On examination of the rocks forming the plateau, these features are found to be due to the fact that they dip to the south-west at the same angle as the general inclination of the surface until near the steep slope above the plains, where they bend over to the south at an angle of about 30°, on the line of the flexure which runs along the southern edge of the Jaintia and Khasia Hills from the Jatinga, north of Silchar, and are quickly buried beneath the alluvium of the plains The geology of the plateau is very simple, and the succession of the rocks is well seen on ascending to it from Rilang Bazaar up the scarp overlooking the Um Blay In the bed of the river and forming cliffs on either side of it rising to 100 feet or so in height, the lowest rock of the plateau, the Sylhet trap, is seen This rock need not be further noticed here Upon it rests the lower beds of the cretaceous series, about 1,000 feet of coarse felspathic sandstone, purple and blue in colour, with strings and lenticular beds of well-rolled quartz pebbles This rock forms a steep scarp immediately over the river, and extends for about half a mile beyond the upper scarp, which rises for another 1,000 feet above it The rocks in the

upper scarp consist of coarse white sandstones becoming finer on ascending, and near the top alternating with beds of indurated clay and coal About 300 feet from the top, a bed of limestone 6 feet thick is crossed This limestone is hard, compact, with a splintery fracture, and contains a few obscure fragments of fossils, but no nummulites The coal occurs close to the top of the scarp at the point marked D on the map The section is described below

On reaching the top of the scarp the path leads for about 5 miles to the west over the surface of the plateau, descending gently to the foot of the ridge called Nongkulang hill Immediately on commencing the ascent of this hill, nummulitic limestone is met with, resting conformably upon the cretaceous rocks below This limestone is about 250 feet thick, and is succeeded conformably by fine ferruginous sandstones of later tertiary age continuing to the top of the ridge On the south the limestone bends over with the cretaceous rocks below, and forms a fringe along the face of the hills, disappearing beneath the alluvium of the plains In this fringe the large limestone quarries belonging to Messrs Inglis & Co are situated

The sections I examined are as follows, the rocks in each case being given in descending order —

A.—This is the section described by Colonel Godwin-Austen (*loc cit*), and occurs in a small ravine in the north bank of the Um Plu, at an elevation of about 850 feet above the stream, 1,250 above the plains —

		Ft	Ins
	Sandstone, coarse, red, and purplish, about	90	0
Seam No 4.	*Coal*	0	8
	Carbonaceous shale	2	0
	Coal	0	8
	Sandstone, white	50	0
Seam No 3	*Coal*	3	8
	Shale, light coloured	8	0
	Carbonaceous sandy shale	1	0
	Shales, light coloured, passing upwards into fine and coarse sandstone	20	0
Seam No 2	*Coal*	3	0
	Carbonaceous shale	3	0
	Coal	1	0
	Carbonaceous shale	2	0
	Sandstone, white, rather coarse	15	0
Seam No 1	*Coal*, whole thickness of seam not visible	6	0
	TOTAL	206	

Total of coal 15 feet

B —In a ravine about 70 feet deep on the path from the Um Plu to the village of Nongyon There is here a seam 11 inches thick at the bottom of the ravine in the right bank overlaid by white and brown sandstones This seam probably corresponds to the upper part of seam No 4 in section A None of the rocks below the coal are exposed, but the presence of the other seams might be easily determined by boring

C —In the gorge of the Um Plu below the village of Nongkerasi The coal occurs at the bottom of the gorge about 270 feet below the village Two seams from 7 inches to a foot in thickness separated by about 2 feet of highly carbonaceous shale can be traced for a considerable distance down the stream, which flows to the west along the strike of the rocks

D —On the path from Nongkerasi to Nongmaotien, about 1½ miles from the latter village, near the top of the scarp over the Um Blay One seam only is exposed 5 feet 6 inches thick, with carbonaceous shale above and below The hill-side is so covered with jungle and talus, that if any of the other seams are present, they are entirely covered up Elevation about 2,000 feet above the plains

E —This is the section I visited and reported on in May 1883 It occurs in a side ravine on the stream flowing into the plains at Borsoragaon to the north of Laour The following is the succession of the rocks seen in the section —

			Ft	Ins
Seam No 4	*Shaly coal*	about	2	0
	Fine yellow sandstone and shale	"	60	0
Seam No 3	*Coal*	"	4	0
	Fine yellow sandstone	"	60	0
Seam No 2	*Coal*	"	3	4
	Shaly sandstone	"	5	0
Seam No 1	*Coal*	"	3	10
		TOTAL	138	2

Total of coal 13 feet 2 inches

The elevation of this section is about 200 feet above the plains

F.—On the path up the hill from the village of Lakma, about 1½ miles west of the last section and 700 feet above the plains, a seam of coal 2 feet thick is exposed, dipping south at 20° The ground above and below is covered with jungle and talus, but a very little excavation would show whether the other seams of section E are present here

At Lakma the fringe of limestone which extends along the southern face of the hills is interrupted for about a mile, this portion having been removed by denudation

G —On a path up the hill from the large limestone quarry about 3 miles west of Lakma This section is very similar to the last, and is at 750 feet above the plains There is one seam 2 feet thick exposed, and dipping to south at 18° It would be worth while, I think, making an excavation at this point also, to determine whether there are any other seams than the one exposed

Two specimens of the coal from section E have been analysed by Sub-Assistant Hira Lal of the Geological Survey, and have given the following results —

	Seam No 1	Seam No 2
Moisture	5 84	3 02
Other volatile matter	35 16	39 58
Fixed carbon	50 40	50 80
Ash	8 60	6 60
TOTAL	100 00	100 00

No 1 does not cake, ash pale red

No 2 cakes, ash red

With regard to the working of the coal, I would recommend that the exposures on the southern edge of the field, those nearest to the plains, should be opened out first, as the cost of carriage from the mines would be reduced to a minimum Then, as the demand for the coal increased, the workings might be pushed further into the hills The coal might, I think, be used with advantage in the burning of the limestone, which is quarried at the foot of the hills At present the limestone is quarried in the cold weather, taken during the next rains to Sunamgunj on the Surma, where it has to remain till the next cold weather, during which it is burnt in a wasteful manner in holes in the river banks, the fuel used being reeds It has then to be stored in the godowns till the rains, when it is carried to market (Dr Oldham, Mem Geol Survey, Vol 1, Pt II, 1858) Two years thus elapse between the time that the stone is quarried and delivered as lime in Calcutta Whereas if the coal on the spot were used, and kilns of the European pattern built, the limestone might be quarried and burnt during the cold weather, and the lime shipped off in the next rains, whereby a great saving in time and labour would be effected The analyses given above show that the coal, owing to the small quantity of ash contained in it, would be excellently suited for burning lime

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Additional notes on the Umaria Coal Field (South Rewah Gondwana Basin), *by* Theodore W H Hughes, A R S M, C E, F G S, *Geological Survey of India*

At the close of my last year's notice of progress in connection with the Umaria coal field, I expressed the hope that another six months would furnish us with data enough to give practical answers to all practical questions I am happy to say that the necessary stage in our investigations has been reached which enables us to do so, and I think I may now write authoritatively as to the capabilities and value of the coal deposits

Questionable thickening of seam

The main point shadowed in doubt was, whether the seam, which at its out-crop measured only 4 feet 2 inches to 4 feet 8 inches, increased to a more efficient thickness to the deep The records of the borings were all in favour of the expression of most sanguine views, but unfortunately the only direct unquestionable evidence as to the behaviour of the coal rather damped the ardour of one's hopes There was no augmentation of the seam in the inclines, though the latter had been advanced some considerable distance to the deep, and expectation had accordingly to be buoyed up by faith in the testimony of the journals handed down by Mr Stewart in 1882

Possible inaccuracy of journals.

There was, however, the possibility that these might have been coloured by the bias of one's proclivities, and that shales, which were nothing more than carbonaceous, had been merged in coal, and thus an excessive proportion of the latter had been registered To those, therefore, who maintained an attitude of incredulity in the

worth of the Umaria field, this contingency and the steadiness of the seam in the inclines lent force to their views

My own position was one of trust in the sections that our preliminary investigations revealed, but in order to leave no room for carping, instructions were given that a test boring should be carried out in the northern area of the field, where the seam was stated to be 10 feet thick, and that if it confirmed our previous knowledge, a shaft should be sunk, to afford facilities for examining the coal and procuring samples of it

Test boring

For the purpose of helping forward the plan of working that I had submitted to Captain Barr, the Political Agent and Superintendent of Rewah, the services of Mr Thomas Forster, M E, were again retained, from 1st November 1883, and with him were associated two young assistant mining engineers, M M Hughes-Hallett and Munsch Their efforts were directed to completing No 1 pit, proving Mr Stewart's No. 9 bore hole, continuing the incline, and commencing a second shaft Matters progressed fairly well during the first month, but great difficulty was experienced in moulding local labour, and it was deemed expedient to introduce contract work

Superintending staff.

After a short trial, it was found to be distinctly advantageous, and an agreement was entered into with Mr Stoney of Katni to pay R10 per foot of sinking for the first 50 feet, and R12 for each subsequent foot up to 100 For driving in the incline R4 a ton was the rate fixed upon

Contract system introduced

Two skilled native fitters and a carpenter were imported from Karharbari to put up the necessary pit head gear and jins, and they worked very satisfactorily They had, however, to be paid high wages, R40 and R30 a month respectively, and as soon as they could be conveniently dispensed with, they were discharged On the western side of India, I am aware that these wages are not considered outrageous, but in Bengal men can be engaged for just one-half the sum we had to offer

Fitters' wages
Carpenter's wages.

With various interruptions from causes that could not be foreseen and guarded against, each shaft was taken down to the coal There was fortunately no difficulty in dealing with water until the seam was reached, a pair of ordinary sinking buckets being quite sufficient to keep the pits dry We were prepared, however, for an influx when the coal was tapped, but though this fear was confirmed in the case of No 1 shaft, strange to say in No 2, where a much larger rush was anticipated, no body of water was met with In one sense, the drowning of No 1 is a favourable sign, as it implies the probability of a more extensive area of coal leading to it than had at first been surmised

Water during sinking

The absence of water in No 2 is perhaps owing to one or more faults cutting off the flow in the direction of the pit This is a mere conjecture offered in response to the natural surprise created by the phenomenal dryness of the shaft Situated as it is in the midst of a very much larger area of coal, and much further removed as it is from the outcrop of the seam than No 1, we certainly inferred that

No excess of water in No 2 shaft.

there would have been a greater volume of water to cope with, but as events have proved, our apprehension was not verified It was an extremely fortunate circumstance for us, as we were spared the necessity of indenting for expensive pumping machinery, and were enabled the sooner to bring our explorations to a decisive issue

The boring intended to check the accuracy of the pioneer journals was put down close to Mr Stewart's No. 9 hole, and it tallied closely with its fellow, the sections being—

No 9 (1882) T. G STEWART, descending

Sandstones and shales

(a)	*Coal*	2' 0"
(b)	Carbonaceous shale	1' 0"
(c)	Carbonaceous shaly sandstone	3' 0"
(d)	*Coal*	10' 0"
(e)	Carbonaceous shaly sandstone	3' 0"
(f)	Carbonaceous shale	1' 0"
(g)	*Coal*	2' 0"
(h)	Carbonaceous shale	1' 0"
(i)	*Coal*	6' 0"
	TOTAL	29' 0"

No 9a (1883). A MUNSCH, descending

Sandstones and shales

	Coal	2' 0"
	Carbonaceous shale	3' 0"
	Carbonaceous shaly sandstone	3 0"
	Carbonaceous shale	1' 0"
(d)	*Coal*	8' 0"
	Carbonaceous shale	1' 0"
	Coal	1' 0"
	Carbonaceous shale	1' 0"
	Coal	1' 0"
	Carbonaceous shale	3' 0"
	Coal	4' 0"
	TOTAL	28' 0"

In No 2 shaft 7' 0" clear coal

Encouraged by the assurance of coal that these returns afforded, we[1] set out the position for the second (or No 2) shaft, within a few yards of the bore holes, and just before the close of the season the seam at (*d*) was passed through and an open view obtained down to that level There are 7 feet of clear coal, and all the stone interpositions that disfigure the seam in the quarry have disappeared with the exception of the clinker band The coal is firm and homogeneous in structure, and has all the promise of being much better in quality than that cut in the incline and which was selected for the Calcutta Exhibition (1883-84)

Tender for 2,000 tons coal, G I. P Railway

A considerable impetus was given to the development of the field, by the acceptance on the part of the Great Indian Peninsula Railway of a tender from the Rewah State to supply 2,000 tons of coal The rate was R13 a ton delivered into the wagons at Katni As neither of the shafts had reached coal, the inclines had to be extended much more than was originally intended, but with the most crude and unfinished labour and system of working, we were in a position to meet easily the demands made upon us, and we could without any anxiety have faced more onerous obligations

Difficulty of carting coal.

The most difficult part of our contract was the carting between Umaria and Katni We had calculated that the Government rate of 3 annas a koss for a load of 14 maunds, or R6-12 a ton, would have secured us as many carts as were requisite to

[1] Mr Hughes was appointed Superintendent of the Rewah Coal Explorations in 1882, and has remained in charge to date —W. K

transfer the coal to the railway, but we found that nothing so favourable could be arranged, and we had to pay from R7 8 to R8-7 to R9-4 a ton for carriage from Umaria to Katni

Good road between Umaria and Katni

There is an excellent fair-weather road from one place to the other, and throughout the 20 miles that it runs in British territory, nearly all the streams are traversed by causeways In making such excessive demands as the carters did, I presume they were reaping out of our necessities, for there could be no reasonable cause of complaint, either about the gradients or the constitution of the road It is almost level throughout, with only one large river (the Mahanadi) to cross, and for one-third of its length it has a serviceable natural metalling of laterite and gneiss

Coal raisings

About 1,600 tons of coal were raised during the season At first the output was small when there were only a few working faces, but as we headed out and more opportunity of getting at the coal presented itself, 12 to 15 tons a day was the average produce The galleries were 6 feet high by 8 feet broad Pillars were 20 feet No accidents occurred to those employed in cutting, and the roof stood perfectly without any artificial support The immunity from casualties that the men enjoyed, encouraged them to persevere in their new occupation, and we have succeeded in laying the foundation of a small mining community I am sorry to say that no attempt was made to teach the use of the pick, either as practised by English miners, or in some modified form, though I particularly wished it, but I trust this omission will be rectified next year Nearly 550 tons of coal were delivered to the Great Indian Peninsula Railway, and 200 tons of slack to Mr Cook, the latter paying at the rate of R8 per 100 maunds at Umaria Mr Cook's object was to have fuel that he could use for lime-burning during the rains, but I have not yet heard whether it was suitable

Running power of coal

To test the running power of the coal on the Great Indian Peninsula Railway, Mr Forster arranged that a trial trip should be made with a full load train Accordingly the local Foreman of the line, Mr Forster, and myself left Jabalpur on the 12th of May 1884 with a baggage train of an average gross weight, excluding the engine and tender, of 410 tons that ran as far as Sohagpur (122 miles) A report of the result achieved has been submitted to the Political Agent of Rewah by Mr Forster, and I prefer in this instance to quote approximately his words

Mr Forster's report

"By the kindness of the Traffic Superintendent, Mr Maurice, we were given a full train load of 32 vehicles The engine supplied by Mr Watson, of the Loco motive Department, was all that could be desired

"We started from Jabalpur at 10 20 P M, 12th May 1884, arriving at Sohagpur about 9 A M on the following morning

"I am exceedingly glad to say that the coal steams admirably, and even when going up hill with the full load, steam was blowing off from the safety valve The fire was cleaned out twice on the journey, not that it was really necessary, but as a precautionary measure against choking During the trip, I noted particularly that very few sparks were thrown out, and that the coal was not more fuliginous than the general run of country coal At starting we had 3 tons 16 cwt

19 lbs of coal on the tender lighting up of engine included The amount of coal left on tender after completing the trip was 1 ton 9 cwt 2 qrs 2 lbs The consumption on the journey was therefore 2 tons 6 cwts 1 qr 21 lbs The evaporation was 5 4 lbs to 1 lb of coal"

Reducing these figures to the standard of pounds consumed per train mile, we have 8,531 lbs —3,330 lbs =5,201 lbs, the actual amount burnt Then $\frac{5,201 \text{ lbs}}{122 \text{ miles}}$ =42 53 lbs per train mile This is only slightly in excess of Karharbari coal, and is far less than Mohpani and Raniganj coal, the comparison being—

Karharbari [1]	Umaria	Raniganj [1]	Mohpani.
40 lbs	42 lbs	51 lbs	55 lbs

The facts now established in regard to the Umaria coal field are—

1st —That there is an abundant store of coal

2nd —That there is a convenient working thickness of at least 7 feet of coal

3rd —That the coal lies within easy access of the surface

4th —That the dip is slight

5th —That there is a good roof to the coal

6th —That the working power of the coal is almost equal to the Karharbari coal

7th —That the coal measures are not heavily watered

Such an array of truths, and the commanding geographical position that the Umaria field holds as an area of supply for Western and North-Western India, render it unnecessary for me to enter into a lengthly advocacy of the expediency of bringing within reach of public use, *with as little delay as possible*, the splendid coal resources of the Rewah State These can only be made available, however, by cheapening the conveyance between Umaria and Katni and substituting for the native gharrywallah a more practical form of carriage

At present the Great Indian Peninsula Railway Company are willing to pay R13 a ton for the Umaria coal, but such a price as this would, in the interests of the coal itself, limit its area of distribution too seriously to be maintained The aim of those who may eventually work the coal field ought certainly to be to reach as far over Central India and the North West Provinces as possible, and one of the essential means to this end is a broad gauge railroad connecting Umaria with the most favourable point on the Jabalpur branch of the East Indian line

It is to be hoped that no unnecessary procrastination on the part of Government will now take place in deciding what course to pursue, so that a cheap market may be thrown open to the mutual advantage of producer and consumer

[1] Extracted from return furnished by the Consulting Engineer to the Government of India for Guaranteed Railways

CALCUTTA,

1st July 1884

ADDITIONS TO THE MUSEUM

FROM 1ST APRIL TO 30TH JUNE 1884.

One sample each of pitch, tar, valveline, mineral tallow, paraffin, batching oil, lubricating oil, and burning oil, manufactured from Burmah earth oil, and a sample of Burmah earth oil.

PRESENTED BY THE 'RANGOON OIL COMPANY,' RANGOON

Sample of a chatoyant jade, called 'cat's eye, said to be from Central Asia.

PRESENTED BY LIEUTENANT COLONEL SIR O B C ST JOHN, K C S I R E

Twenty seven specimens of clays, glazing materials, and pigments, used in the manufacture of Indian pottery at the Bombay 'School of Art'

PRESENTED BY B. A GUPTE, HEAD CLERK, 'SCHOOL OF ART,' BOMBAY

A model of the 'Gor do Nor' diamond, recently found in the Bellary district, Madras Presidency

PRESENTED BY MESSRS P ORR AND SONS, MADRAS

Thirty two specimens of rocks from Dalhousie region

PRESENTED BY COLONEL C A McMAHON, F G S, DALHOUSIE

Specimens illustrating the malleability of sheet iron used for tin plate making, from the 'Wilden Iron Works, near Stourport, England

PRESENTED BY MESSRS E P & W BALDWIN, ENGLAND

A palæolithic implement, from surface of laterite, near Katangi, Katni tahsil, Jabalpur district found and presented by Mrs W King

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THE AUTHOR

BAYLEY, THOMAS —A pocket book for chemists, chemical manufacturers, metallurgists, dyers, distillers, brewers, sugar refiners, photographers, students, &c 2nd edition 12° London, 1881

BELL, ALONZO —Report on the hot springs of Arkansas made to the Secretary of the Interior 8° Pam Washington, 1882

HOME DEPARTMENT

BOWERBANK, J S —A monograph of the British Spongiadæ Edited, with additions, by A M Norman Vol IV (Ray Society) 8° London, 1882

BRADY, G STEWARDSON —A monograph of the free and semi parasitic Copepoda of the British Islands Vols II—III (Ray Society) 8° London, 1880

BROECK, ERNEST VAN DEN —Note sur un nouveau mode de classification et de notation graphique des dépots geologiques basé sur l etude des phenomenes de la sedimentation marine 8° Pam Bruxelles, 1884

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BUCKTON, GEORGE BOWDLER —Monograph of the British Aphides Vols III IV (Ray Society) 8° London, 1881 & 1883

CAMERON, PETER —A monograph of the British Phytophagous Hymenoptera (Tenthredo, Sirex and Cynips, Linné) Vol I (Ray Society) 8° London, 1882

CAPELLINI, G —Della Balena di Taranto confrontata con quelle della nuova zelanda e con talune fossili del Belgio e della Toscana. 4° Pam Bologna, 1877.

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COLLINS, J H —Mineralogy Vols I—II 8° London, 1878 and 1883

DUMONT, J B —Synoptical tables of modern Chemistry Vol I Inorganic Chemistry, part 5, Metals—Manufactures 8° Calcutta, 1884

DUPONT, EDOUARD —Notices préliminaires sur les fouilles exécutées sous les auspices du Gouvernement Belge dans les cavernes de la Belgique Tome I 8° Bruxelles, 1867

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Geology of Wisconsin. Vols I and IV With Atlas 8° Madison, 1883 and 1882

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HYATT, ALPHEUS —Genera of Fossil Cephalopods 8° Boston, 1883

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JERVIS, GUGLIELMO —I Tesori Sotterranei dell' Italia Vols I—II 8° Torino, 1873—74

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KING, WILLIAM.—Geology at a glance 5th edition 4° Pam Dublin, 1863

WILL KING, ESQ

" Synoptical table of aqueous rock groups, chiefly British, arranged in their order of superposition and chronological sequence 8° Pam Dublin, 1863

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KING, WILL —Notice of a pre historic burial place with cruciform monoliths, near Mungapet in the Nizam s Dominions 8° Pam Calcutta, 1877

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" Des Puits Artésiens a Pondichery, et de la possibilité de recouvrir de sources semblables à Madras 8° Pam Pondichéry, 1880

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Paléontologie Française 1re Série, Animaux Invertébrés, Terrain Jurassique, livr 67 and 68 8° Paris, 1884

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Quarterly Journal of Microscopical Science New Series, Vol XXIV, No 94 8° London, 1884
Zeitschrift fur Naturwissenschaften Folge IV, Band II, heft 6, and Band III, heft 1 8° Halle, 1883 1884
Zoological Record for 1882 Vol XIX 8° London, 1883

GOVERNMENT SELECTIONS, REPORTS, &c

ASSAM —Report on the Administration of the Province of Assam for 1882 83 Flsc Shillong, 1884.

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BOMBAY —Selections from the Records of the Bombay Government New Series, No 163 8° Bombay, 1883

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INDIA —List of Civil Officers holding gazetted appointments under the Government of India in the Home, Legislative, and Foreign Departments, as it stood on the 1st January 1884. 8° Calcutta, 1884

HOME DEPARTMENT

,, Registers of Original Observations in 1883 and 1884, reduced and corrected September 1883 to January 1884 4° Calcutta, 1884

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,, Report on the Census of British India, taken on the 17th February 1881 Vols I and III Flsc London, 1883

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BATAVIA.—Notulen van het Bataviaasch Genootschap van Kunsten en Wetenschappen Deel XXI, Nos 3-4, and XXII, No 1 8° Batavia, 1884
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" Naturkundig Tijdschrift voor Nederlandsch Indie Deel XLIII 8° Batavia, 1884
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" Tijdschrift voor indische Taal Land en Volkenkunde Deel XXIX, Afl 2 4, and XXX, Afl 1 2 8° Batavia, 1883 1884
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" Proceedings of the Boston Society of Natural History Vols XXI, pt 4, and XXII, pt 1 8° Boston, 1883
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" Proceedings of the American Academy of Arts and Sciences New Series, Vol X 8° Boston, 1883
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BRISTOL.—Bristol Museum and Library Report of Proceedings at the 13th annual meeting, held 21st February 1884 8° Bristol, 1884
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BRUSSELS —Bulletin de la Société Royale Belge de Géographie Année VII, No 6 8° Bruxelles, 1883

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CALCUTTA —Journal of the Agricultural and Horticultural Society of India. New Series, Vol VII, pt 2 8° Calcutta, 1884

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„ Journal of the Asiatic Society of Bengal New Series, Vol LIII, pt I, No 1 8° Calcutta, 1884

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„ Proceedings of the Asiatic Society of Bengal No X (1883), and Nos I—III (1884) 8° Calcutta, 1883 and 1884

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„ Palæontologia Indica Series X, Vol II, pt 6, Series X, Vol III, pt 1, and Series XIII, Vol I, pt 4 fasc 3 4° Calcutta, 1884

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„ Records of the Geological Survey of India Vol XVII, pt 2 8° Calcutta, 1884

GEOLOGICAL SURVEY OF INDIA

„ Report of the Archæological Survey of India Vol XVII 8° Calcutta, 1884

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LAUSANNE —Bulletin de la Société Vaudoise des Sciences Naturelles 2me Série, Vol XIX, No 89 8° Lausanne, 1883

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„ Journal of the Royal Asiatic Society of Great Britain and Ireland New Series, Vol XVI, pt 1 8° London, 1884

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„ Journal of the Society of Arts Vol XXXII, Nos 1633—1646 8° London, 1884

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„ Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland. Vol IV, No 20 8° London, 1881

„ Proceedings of the Royal Geographical Society New Series, Vol VI, Nos 2—4 8° London, 1884

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„ Proceedings of the Royal Institution of Great Britain Vol X, pt 2, No 76 8° London, 1883

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LONDON—Proceedings of the Royal Society Vols XXXV, No 227, and XXXVI, No 228 8° London, 1883

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„ Quarterly Journal of the Geological Society. Vol XL, Part 1, No 157 8° London, 1884

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„ Mémoires de la Société Géologique de France 3me Série, Tome III, No 1 4° Paris, 1884

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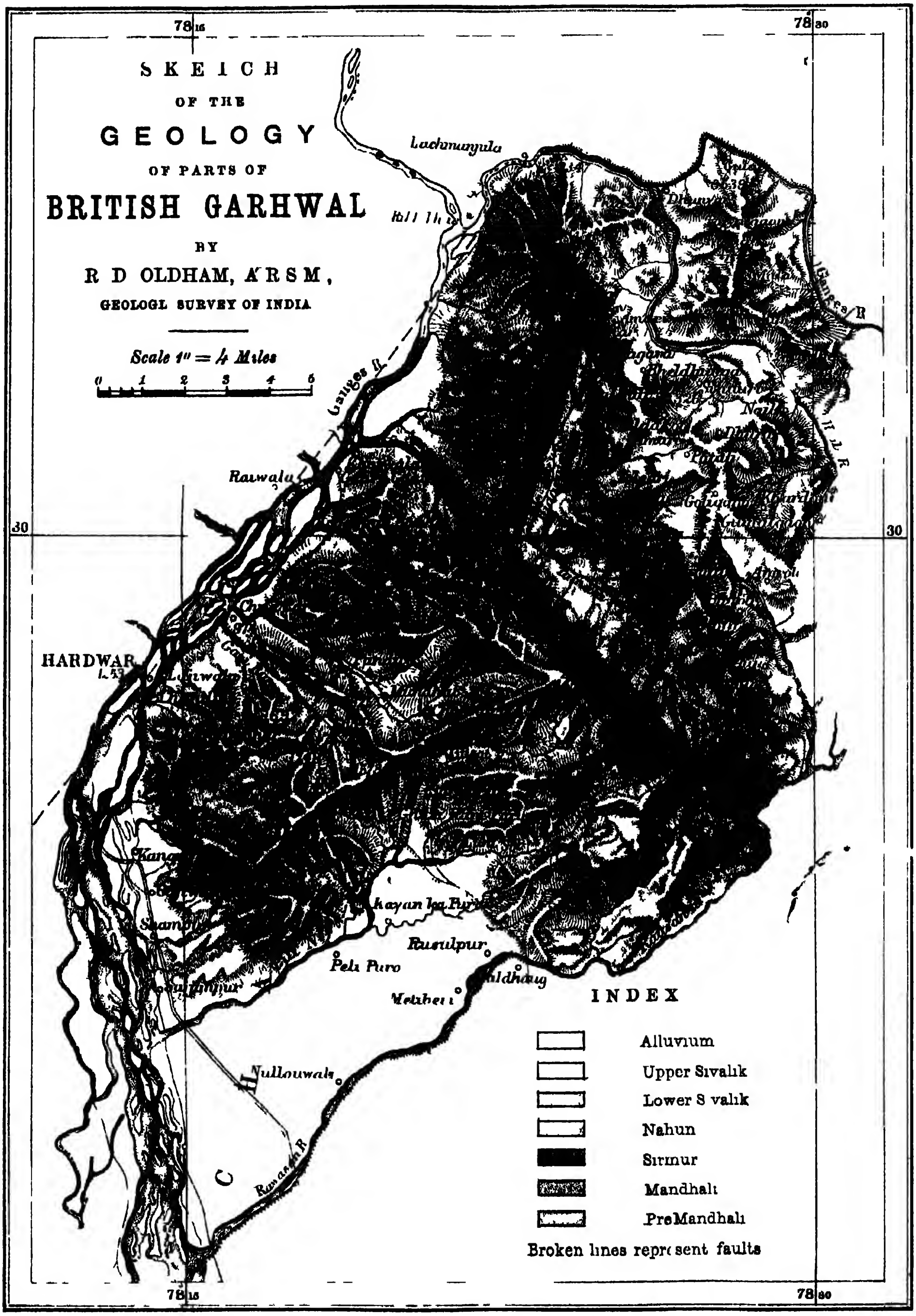
SKETCH
OF THE
GEOLOGY
OF PARTS OF
BRITISH GARHWAL
BY
R D OLDHAM, A R S M,
GEOLOGL SURVEY OF INDIA
Scale 1" = 4 Miles
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78 15
78 30
30
30
Ganges R
Rawala
HARDWAR
Rasulpur
Peli Puro
Nullouwala
Ganges R
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Alluvium
Upper Sivalik
Lower Sivalik
Nahun
Sirmur
Mandhali
PreMandhali
Broken lines represent faults

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1884 [November

Note on the Geology *of part of the* Gangasulan Pargana *of* British Garhwal, *by* R. D. OLDHAM, A.R.S.M., &c., *Geological Survey of India.* (With a map.)

1. The country to be described in this note is comprised within a strip about 5 miles broad, stretching eastwards from Rikhikhes and southwards to the foot of the Chandi hills, lies entirely to the east of the River Ganges, and presents more points of geological interest than any other Himalayan tract of equal magnitude with which I am acquainted.

Older series.

2. The oldest rocks seen I have comprehensively coloured on the map as 'Pre-Mandhâli.' With the exception of some beds of limestone exposed to the north of Latchman Jhula in the bed of the Ganges they are, to the east of the strip of Mandhulis and Sirmurs, grey schists or slates with occasional beds of quartzites, and to the west as far as the recent deposits of the Ganges black slates with quartzites and occasional calcareous beds, presenting no features of geological interest apart from the marked and sudden manner in which their strike bends round with the irregularities of the boundary of hill and plain, being northwards between the parallel of Rikhikhes and the Bheng Nadi, but bending sharply round to east and westwards immediately to the north and south of those limits, the courses of the Bedasni and Tal nadis marking the strike of the rocks they run through, while their junction is at the point where the one strike bends round to the other.

Mandhâli series

3. The Mandhali beds, under the name of Tal limestone, have long been known and have acquired a celebrity as the only case known of fossils being found in the pretertiary beds of the lower Himalayas; the section in the Bedasni has been already described in detail,[1] and the only addition I have to make is that an examination of the same beds in their extension along the Syair ridge shows that they lie in a synclinal and not anticlinal fold. Along the ridge they broaden out and form its high and rocky

[1] Rec. G. S. I., XIV, 100.

crest, and here limestone conglomerates of the regular Mandháli type are seen associated with the fossiliferous beds Near (a short way to the south of) the village of Syair the eocene beds come in to the east, the junction with the Mandhális being one of original contact as is marked by the occurrence of the characteristic bottom bed of the Subathu series, from here the Subathu-Mandhali boundary runs to the north, keeping on the east of the ridge till a gap just north of Karanwas village, whence the ridge changes its character and a broad rolling summit replaces the rocky crest to the south, and here, in the gap, the ferruginous bottom

Of pretertiary age

bed of the Sirmurs can be seen *lapping round the eroded edges of the Mandháli limestone* This is a point of great interest and importance in proving that the Mandháli series is of pretertiary age, as was inferred by me on other and more general grounds [1] The boundary runs down about a furlong and a half from the crest of the ridge, but once more mounts on to it to the north of Bhuwan and runs away north-eastwards towards Toli Along this part of the boundary the bottom bed is not so well seen, but as there are distinct traces of it in places, we may consider this also as a natural boundary The great mass of the hill above Marhal is Mandhali limestone, some of the beds fossiliferous, others conglomeratic, but many of them structureless limestone with which, as further to the south, slates and quartzites are interbedded

Mandhális of the Banas ridge

4 To the south of the Bheng river these beds are seen on the crest of the Banas ridge extending close to, if not actually up to, the outcrop of Sirmurs, but they are not seen at its eastern extremity Near the western boundary of the exposure there is a peculiar ferruginous breccia which seems to belong to this series, though for want of good exposures it is impossible to say whether it may not be of superficial origin

No recognizable fossils

5 It would have been of great interest and importance as giving us a definite horizon in the Himalayan rocks, had any recognizable fossil been found in these beds, but I regret to have to say that a diligent search has met with no such reward The shells, though all recognizable as such and well preserved, have been comminuted so as to form a sort of shell grit among which no pieces large enough to afford more than a very vague generic identification could be seen The bed is evidently of littoral origin and this comminuted state of the shells, if preventing an accurate comparison of the horizon of the bed with European standards, was at any rate useful in readily discriminating it from the somewhat similar limestone beds of the Subathu series in which the shells were all entire or only slightly broken

Subathu beds
Bhuwan outcrop

6 The next series seen, in ascending order, was the Subathu Of this the exposure near Bhuwan has been described as regards its character [2] Its western boundary has already been referred to in connection with the Mandháli series, while the eastern is a fault, along this boundary the bottom rock is not seen and the beds immediately in contact with the grey schistose slates are somewhat high up in the series

[1] Rec G S I, XVI, 197 §17 [2] Mem G S I, III, p

Subathus of the Banas ridge

7 To the south of the Tal nadi there is another exposure of these beds Of this I have only seen the eastern and western extremities, but there is no doubt that it extends continuously between the two, as within these limits all the lateral feeders of the Tal which flow from the south contain débris recognizable as derived from the Subathu series At the eastern extremity only was the bottom bed seen, so that this strip may be faulted in

Sub Himalayan Rikhikhes

8. The most northerly exposure of the sub-Himalayan beds is that opposite Rikhikhes, which has been mentioned as of Nahan age—[1] an opinion from which I find myself obliged to dissent The exposure, whose boundaries are completely obscured by recent river gravels, consists of soft grey sandstones and sandy clays with a north by west strike and vertical dip, which, from their resemblance to the middle Sivalik beds and the entire absence in a section of some considerable thickness of any trace of the very characteristic red clays of the Nahan beds, I would refer to the former rather than the latter period This is, however, a matter of opinion, and no definite proof can be adduced of one or the other conclusion

Bheng Nadi

9 The supposition advanced is, moreover, supported by the fact that the next exposure to the south, that in the Bheng nadi, contains very characteristic red clays undistinguishable from those of Nahan age in the Nahan hills Between these two exposures the older Himalayan slates everywhere come into contact with the recent gravels, while immediately north of the Bheng a spur of the older rocks juts out a full quarter of a mile to the west of the outcrop of tertiary clays, showing that their boundary must here take a sudden bend westwards

Banas ridge

10 South of the Bheng the tertiary sandstones come into contact with the sub-recent gravels of the Ganges and continue up the Banas ridge to the gap between the two trigonometrical points marked on the 1-inch map Between this point and the exposure in the Bheng I was unable to trace the boundary of the tertiaries It would have been important to determine how the main boundary coming up from the south-east bends round to take in the Bheng exposure, but in the absence of definite observations I have been compelled to draw it on the map in the manner which seems best to fit in with observations elsewhere, it is, however, only conjectural, and must be taken for what it is worth From the Bheng exposure southwards the section is on the whole an ascending one, the dip at the western extremity of the Banas ridge being to east-south-east, while the beds are soft yellowish-grey sandstones and sandy clays without a trace of red clay

Ghaziram Sot.

11 South of Jamnia bagh I saw no exposures till the Ghaziram Sot was entered, here soft sandstones with concretionary nodules of harder rock, and, higher up, conglomerates dip at first eastwards and westwards at low angles, settling down near the head of the stream to a steady northerly dip at about 30° It is a noteworthy fact that both the sandstones and conglomerates contain numerous pebbles of soft tertiary sandstone

[1] Mem G S I, III, 116 Rec G S I, XIV 100

12 In the Mithi Sot, just where the old road from the Jabbar Gadh to Laldang crosses it, there is an exposure of soft pebbly sandstone, some of the pebbles being of sub-himalayan sandstone, with a vertical dip, striking to north by west At the base of the exposure and lying east of the sandstones is a low bank o' dark-red clay, possibly of Nahan age—a possibility which is rendered probable by the fact that the next exposure up stream is of compact sandstone breaking off along defined joint planes, interbedded with red nodular clays of the Nahan type having the same north by west strike The continuation of this line of strike leads to a point on the Banas ridge, where I noticed a marked change in the nature of the débris lying on the surface of the ground, all the fragments to the west being thoroughly rounded by weathering, while those to the east generally retained some traces of the joint planes along which they had broken off and were not uncommonly sub-angular Continued still further northwards, it would form the eastern boundary of the Bheng outcrop These facts would seem to point to the existence of a line of fault, a consideration to which I shall subsequently return, but, whether a fault or no, it is the boundary between the Nahan beds to the east and the middle and upper Sivaliks to the west In this same stream there are many boulders of a peculiar rock, a fine-grained micaceous sandstone undistinguishable from the Nahan sandstones but for the fact that scattered through it are sub-angular fragments of crystalline quartzite mostly 9′ to 1′ in diameter, none that I saw being larger and few much smaller I did not see this rock *in situ*, but as the boulders of it increase in number up stream, and as they were seen above (to the east of) the line of junction, they must have been derived from the Nahan beds, notwithstanding the fact that nowhere else is so much as a pebble known from beds of undoubted Nahan age

Mithi Sot

13 On the eastern flank of the Chandi Hills, at about half a mile from Diowali, and just where the road from the north crosses the Khara Sot for the fourth and last time, an important section is to be seen Here there is a long cliff of upper Sivalik sand-rock, earthy clay and shingle, to the south, soft grey pebbly sandstones come in with a dip of 30° to east by south, the actual contact not being seen No pebbles of sandstone were found in the latter, but numerous red-clay galls, some evidently derived from clays of older date as they were laminated, the laminæ not agreeing in direction with those of the sandstone This fact, together with their softness and the absence of beds of red clay, seems to stamp them as of middle Sivalik rather than Nahan age The exposure terminates to the south by the slope of the hill-side passing off into the level ground, but before altogether disappearing, the hill sends out a small spur northwards into the stream, it is a small knot 10 feet long, 9 feet broad, and 6 feet high, on the up-stream side of which a hollow has been excavated in the river-bed such as is invariably found above any obstruction to the force of the current Here a triangular surface of the sandstone beds is seen on whose eroded edges upper Sivalik conglomerates, containing many pebbles of sub-Himalayan sandstone and clay, lie with a dip of 45° to east by south That this is not a mere case of contemporaneous erosion is proved by the facts that while the dip of the conglomerates

Diowali

A contact section

is 45° that of the sandstones below is only 30°, and that the boundary of the sandstone beds is not smooth and uniform, but irregular, the hard beds standing out with a sub-angular section proving that they must have been indurated, disturbed, and eroded previous to the deposition of the conglomerates above

Chandi Hills

14 To the south of a line running west of this the Chandi Hills are mainly composed of middle Sivalik sandstones, but are frequently capped by thin patches of the upper conglomerates, let in by local faulting or flexure, which were not mapped in detail There seems but little doubt that it was these upper beds which yielded the fossils discovered by Dr Falconer[1] and more recently by Mr Lichfield in 1883

Nature of boundary

15 I now come to the consideration of the question whether the meridional boundary described above (para. 12) as existing between the Nahans and upper Sivaliks is to be considered as mainly due to faulting, or whether it approximately marks out the area over which the Nahans were removed by denudation previous to the deposition of the upper beds That there was an extensive denudation of the Nahans previous to and during the deposition of the upper Sivaliks is sufficiently proved by the number of pebbles of the former to be found in the latter, but this may have been general and not largely greater near the Ganges than elsewhere, while there is no such direct proof that they were being eroded during the deposition of the middle Sivalik sandstones which are in contact with them on the Banas ridge I saw no pebbles of sandstone in the middle Sivaliks, and if present they must be rare, but as the only pebbles to be seen are small, well rounded, and of hard quartzite, this negative evidence goes for very little On the other hand, the straightness of the boundary, the contrast of the beds in contact, and the vertical dip, all go to prove that, even if the boundary is approximately one of original deposition, it must have been considerably modified by faulting or its practical equivalent

Probably a fault

16 In this connection the small exposure of Sub-Himalayan beds in the Bheng is of principal importance, their position (apart from a possible though hardly probable fault in the Bheng valley) is at the base of a section ascending to the southwards, the upper beds being of middle Sivalik age which the Bheng beds, if Nahan, as their character almost necessitates, must unconformably underlie In this case there is a small patch of Nahans cut off entirely from the main mass to the south-east, and if we suppose that the boundary between the Nahans and the newer beds marks even approximately the area over which the former were removed previous to the deposition of the latter, we must account for the fact that the Bheng exposure has been brought up to the surface by faults, which both to the north and east have their downthrow on the side nearest to it, consequently if the Bheng outcrop is of Nahan age, the rocks to the east of the meridional fault must have been elevated and the newer beds removed by denudation, and the Nahans must originally have extended to the north of their present boundary, which must in that case be mainly due to faulting

[1] Journ A S B VI, 233

17. A similar issue to the last is raised by the contrast between the beds exposed at Raiwala on the west bank of the Ganges and those seen opposite them to the east. At Raiwala an exposure has been described[1] of upper Sivalik clays and conglomerates lying in an anticlinal flexure whose steeper side faces north, while to the east of the Ganges we find opposite these beds and on the same line of strike low middle Sivalik sandstones forming part of a large synclinal. Leaving the question of flexure on one side, for that at Raiwala is insignificant in size and might well lie on the flank of a much larger one, there is the difference in the horizons of the beds, those at Raiwala being high up in the upper Sivaliks, while opposite them are low middle Sivaliks if not Nahan beds—presumptive evidence of a great fault running in the bed of the Ganges with an upthrow to the east. This might, however, be explained away by the unconformity which, as I have shown above (para. 13), does exist in this region between the middle and upper Sivaliks; but, on the other hand, the continuation of this presumed fault would lead into the proved fault in the Hardwar gorge, and though this latter has a downthrow to the east, the great Bhimgoda fault, with a throw of some 15,000 feet, which almost, if not entirely, dies out against the former, would sufficiently account for any reversal of the fault to the northwards.

Boundary at Raiwala.

18. In this connection I may review the facts which show that these faults can nowhere be considered as simple dislocations, on one side of which the beds have been elevated, and on the other depressed, but that they are contemporaneous with, and have been formed *pari passu* with, the disturbance of the beds they intersect. In the Hardwar gorge, as has long been known,[2] a northerly dip of the beds to the east is confronted by a southerly dip to the west, and if, as seems probable, the lowest beds on the Chandi section are lower in the series than the beds opposite them on the Hardwar side, the fault must have an upthrow to the east hereabouts, while further north opposite Bhimgoda the upthrow is certainly to the west. In this case there must be some point in the Hardwar gorge where the throw is *nil*. Even if this supposition is incorrect, the throw of the fault must increase rapidly towards the north, and in either case we cannot consider the fault as of later date than the flexure of the beds, but must look upon it as a line of fracture, on one side of which the beds were from the first bent in one direction and on the opposite in the other.

Nature of faults. Hardwar fault.

19. Turning now to the Bhimgoda fault, which, as I have said, does not seem to cross the Ganges at all, and if it does so only in a very modified form, we can hardly suppose it to have been of altogether posterior date to the formation of the Sivalik anticlinal, for the beds at the top of the section north of the fault are the very newest that we can call Sivalik with certainty, and had they ever been elevated and exposed to denudation must have been from their softness largely removed; it consequently becomes probable that in this case too the formation of the fault was gradual and progressed *pari passu* with the flexure of the beds it affects, rather than

Bhimgoda fault.

[1] Mem. G. S. I., III. 124.
[2] *Vide* H. B. Medlicott, Mem. G. S. I., III, 123.

that these beds were thrown into an anticlinal and the northern half then depressed

20 This great downthrow of the Bhimgoda fault more than neutralizes the upthrow of the Hardwar fault, and consequently we find the beds facing those immediately north of the Bhimgoda fault seem to be lower in the series, arguing a northerly extension of the Hardwar fault, but with a *downthrow* to the west Northwards the more rapid dip of the eastern beds soon extinguishes this throw until, near the Zabhar Gadh, the sudden replacement of the upper Sivaliks by middle Sivaliks seems to argue a fault coming from the east in some respects the analogue of the Bhimgoda fault Be this so or not, to the north of this point at Raiwala the fault must have an upthrow to the east of some thousands of feet That this complicated system of faulting is of altogether posterior date to the disturbance of the beds is impossible, and the only conclusion we can draw is that these faults must have been gradually formed contemporaneously with the disturbance, and to some extent the deposition of the beds they affect

Northern extension of Hardwar fault.

21 To this fault in its extended sense I propose to give the name of the Ganges fault From the mouth of the Hardwar gorge I have traced it as far as Raiwala, but to the north of this there are still indications of its existence To it is possibly due the elevation of the pretertiary beds which has cut out the sub Himalayan series from the Bheng northwards to Rekhikhes, and it may even extend further north into the older rocks of the lower Himalayas, but this cannot be decided except by further examination

Ganges fault

22 The post-pleiocene river gravels are largely developed along the western boundary of the area under description, but as they differ in no respect from those of the Dehra Dún, which I hope shortly to describe at length, it will be unnecessary to refer to them here further than to mention that they cover much of the ground which I have coloured as some older formation on the accompanying map

Post pleiocene

23 Near Jamnia bagh, about quarter of a mile to the north of the camping ground, a small warm spring issues with a temperature of 73° F on the side of a channel which has been dug to carry off the waste water from a water-mill The water of the spring is pure and sweet, so that its temperature cannot be due to chemical action, and it is important to notice that it issues close to the line which I have indicated (para 20) as probably a line of fault I was informed by the natives that another warm spring had been struck near Gouree ghât a few years ago when making an irrigation cut This latter seems to have been a failure, as a dry channel was pointed out to me whose bank had certainly been cut into at one place, but there was no warm spring My informant reconciled this with his statement by explaining that the hole had been filled up since On the whole the existence of this warm spring is doubtful, but it is noteworthy that the locality pointed out to me lies on the northerly extension of the Ganges fault

Warm springs

On fragments of slates *and* schists *imbedded in the* gneissose granite *and* granite *of the* N.-W. Himalayas, *by* COLONEL C. A. MCMAHON, F.G.S. (With a plate.)

In my paper on the Simla Himalayas (Records, X, p. 221) I recorded the following note regarding the eruptive granite of the upper Sutlej section: "Between Rarang and Jangi I found numerous blocks of mica schist caught up by and buried in the granite. They are of all shapes, and vary in diameter from 2 inches to 2 feet. These blocks are identical in appearance and composition with the mica schists through which the granite passes, and cannot, I apprehend, be due to segregative action."

Similar inclusions are to be observed in the gneissose granite at Dalhousie and its neighbourhood. In my paper on the Geology of Dalhousie,[1] I recorded the following note respecting them: "For some time I regarded these objects as concretionary in origin, but the conclusion was ultimately forced on me that they are true fragments of the adjoining schists, caught up by the granite in its passage through them. They are more numerous close to the schists than away from them; they closely resemble the schists in colour and material; and, in the Chuari section, where the porphyritic granite has been squeezed into and between the schistose beds, fragments of schists may be seen caught in the act, so to speak, of being broken off.

"Some of the included pieces—even those seen a long way from the junction of the granite and the schists—seemed to me of undoubted fragmentary origin. One, for instance, which I noticed in the Chuari section, was a long splinter 2 feet 4 inches long, and 5½ inches wide at the thickest end. In its splintery ends it seemed to give clear evidence of having been torn from its parent rock. It stood out sharply from the granite, and it was fractured transversely in several places, the cracks not penetrating into the granite."

As might be expected, on the supposition that the inclusions alluded to are really fragments of other rocks imbedded in an eruptive granite, the Jángi and Dalhousie specimens do not resemble each other at all; but, on the contrary, in most cases, are very like members of the local sedimentary strata through which the granite has penetrated.

I have now examined under the microscope thin slices of the Jángi inclusions, and of the mica schists at Jángi through which the granite has been erupted, and I have also examined specimens of the Dalhousie inclusions, and have compared them with the granite itself, and with the silurian beds found in the neighbourhood. The results are given in the following pages.

I shall, as usual, describe each slice in some detail, and then summarise the results under the head of "General Remarks" at the end.

No. 1.—Mica schist between Rogi and Pangi. A dense rock containing numerous small garnets.

No. 2.—A fine-grained dense mica schist. Pángi (Bassáhir).

M.—In No. 1 the mica is of rich Vandyke brown colour in transmitted light. The ground mass consists of quartz with a few crystals of felspar. Garnets are numerous. Parallelism of structure is not apparent in the arrangement of the mica

[1] Rec. G. S. I., XV, p. 49.

In No 2 the mica appears to be in part biotite and in part muscovite, the basal cleavage is well marked in both The mica is oriented in all directions, but a general conformity to a parallelism of arrangement can be made out, and extinction is simultaneous in the great majority of leaves Garnets are present In the ground mass felspar predominates over the quartz The former is in part microcline, and in part plagioclase

In neither of the specimens did I detect a single liquid cavity with a bubble in it

Nos 3 and 4 —Mica schist included in granite between Rarang and Jángi

M —Numerous flakes of mica, the axial sections of which are a rich Vandyke brown in transmitted light, are disseminated through a quartz ground mass

One or two crystals of muscovite are also present The quartz contains numerous rounded microlites of mica

I failed to detect a single liquid cavity with a bubble in this slice, though I used powers up to 400 linear

These inclusions have evidently been subjected to great heat, but the entire absence of felspar, and of the liquid cavities with movable bubbles so characteristic of the quartz of granite, marks them off from that rock Moreover, the character of the mica is suggestive of a schist rather than of a granite It is in flakes, and the majority of the leaves lie in the same plane

No 5 —Granite between Rarang and Jángi with contained inclusion With the aid of a pocket lens this inclusion is seen to consist of the constituents of granite in an extremely fine-grained condition The line of demarcation between the inclusion and the granite is sharp and well defined

M —The examination of this specimen under the microscope confirms the result of the examination with the aid of the pocket lens The slice contains a portion of the granite and also a portion of the inclusion The latter contains both orthoclase and plagioclase, as well as quartz In structure and in every particular it is a granite The microlites seen in the slice contain shrinkage vacuoles and cracks Flat liquid cavities with fixed bubbles are extremely abundant, whilst those with movable bubbles are not altogether wanting

Dalhousie

No 6 —Inclusion in gneissose granite—Upper Mall, Bakrota A dark, fine-grained mixture of quartz and mica, with irregular-shaped pieces of felspar here and there

M —The slice is composed of quartz, dark mica, muscovite, crypto crystalline mica, garnets, magnetite or ilmenite, and ferrite

The quartz contains gas pores and liquid cavities with movable bubbles Microlites containing shrinkage vacuoles and liquid cavities, with movable or fixed bubbles, are numerous One micro-prism contains liquid cavities

The whole aspect of this slice under the microscope is that of the granite which contains the inclusion

No 7 —Inclusion in gneissose granite—Upper Mall, Bakrota

M —This slice shows the junction of the granite and the inclusion The latter looks like an intensely altered slate, and, under the microscope its aspect is very different from the last specimen

The inclusion is composed of quartz and biotite with some magnetite, or ilmenite, and a little crypto-crystalline mica in patches

A small piece of felspar is entangled in crypto-crystalline mica, but it exhibits no crystalline contour There are a few microscopic garnets. The quartz contains some liquid cavities with movable bubbles, and some of the microlites contain vacuoles The rock has the appearance of being an intensely altered slaty rock.

No 8 —Inclusion in gneissose granite—Upper Mall, Bakrota.

M —This slice consists of a ground-mass of quartz in micro-grains, in which are scattered a dark mica (biotite ?) in leaves, and in well-laminated crystals, small leaves and microlites of muscovite, patches of crypto-crystalline mica, garnets, and magnetite or ilmenite

The quartz encloses liquid cavities with movable bubbles, and microlites which contain elongated vacuoles and cavities in which mineral matter has been deposited

There is no trace of felspar

Between Dalhousie and Chil

No 9 —Inclusion in gneissose granite The hand specimen and the thin slice show the junction of the included dark slaty rock and the granite

M —The granitic portion of the slice contains orthoclase, microcline, plagioclase, muscovite in large leaves and in microlites, and well-laminated biotite There are numerous intergrowths of biotite and muscovite, and crystals of the former enclose garnets

Grains of ilmenite or magnetite are common to the granite and the slaty enclosure The latter consists of granular quartz, a green mica, and numerous patches of micro-crystalline mica, which passes here and there into small leaves of muscovite A few small garnets are present, but no felspar

The quartz of the granite contains movable bubbles, but I have not detected any in the slaty inclusion

Upper road near top of Bakrota, Dalhousie

No 10 —Inclusion in gneissose granite To the unaided eye this looks like a compact rock with a pocket lens it is seen to be sub-crystalline It exactly resembles some rocks of the silurian series

M —This slice consists of an intimate mixture of very fine-grained quartz and mica The quartz has evidently recrystallised under the influence of heat, as its minute grains exhibit a tendency to assume hexagonal outlines The mica is of two kinds,—a green mica, and what is apparently muscovite The former is by far the more abundant, stray leaves of muscovite only appearing here and there There is one good sized leaf of green mica, but the rest is in micro-flakes

A little hæmatite and magnetite are present There are numerous microlites, but all of them are apparently of mica

I have not detected any liquid cavities in the quartz

The microscopic examination of this slice leads to the conclusion that it is a fragment of slate that has been exposed to considerable heat

No 11 —Inclusion in gneissose granite This specimen is so like No 10 that a separate description is unnecessary Both specimens under the microscope closely resemble some of the slaty rocks immediately adjoining the gneissose

granite at Dalhousie The only difference is that in these specimens the heating has gone sufficiently far to almost obliterate the lamination The materials are not arranged in well-defined lines, but still one has no difficulty in making out which way the grain goes

The muscovite is not in clear leaves, as in granite, but fibres of the green mica are abundantly entangled in it

Nos 12-15 —A fine grained schist included in gneissose granite Upper Road, near top of Bakrota In 13, 14, and 15 the hand specimens, and also the thin slice, show the junction of the granite and the schist

M —The granite is of the usual type, already described in previous papers under the name of gneissose granite

The ground mass of the schist is composed of quartz in fine grains There is no felspar The mica varies in different slices in transmitted light, from yellow-green and brown-green, to brown It is in large and small flakes, some of them being very minute and also in well laminated crystals Muscovite, crypto-crystalline mica, and schorl, are also present There are round dots of opacite and a little magnetite

The granite and the included schist contrast strongly with each other in the matter of liquid cavities with movable bubbles The quartz and the schorl of the granite contain liquid cavities with large movable bubbles the areas covered by the latter are about one fourth of the areas of the cavities that contain them In the schist, on the other hand, I have failed to detect any liquid cavities in any of the slices

General Remarks

The microscopic examination of the specimens described in this paper leads to the conclusion that, in some cases, what appear to be fragments of other rocks contained in granite are either inclusions that have been so intensely metamorphosed, and thoroughly permeated with the mineral constituents of the granite, that they have become granitic in structure and composition, or that portions of the granite itself have locally condensed into fine-grained concretionary lumps resembling true inclusions in appearance Slices Nos 5 and 6 are instances of such cases

On the other hand, the microscope confirms the verdict arrived at by the unaided eye in respect of the majority of cases, and shows that what appear to be inclusions are really fragments of foreign rocks caught up and inclosed in the granite

Three classes of true inclusions have been examined,—namely, ordinary mica schists, slaty rocks, and fine grained silicious schists

The inclusions found in the eruptive granite of the Sutlej valley present under the microscope the strongest likeness to the bedded mica schists through which the granite has burst

In the case of the slaty inclusions in the Dalhousie gneissose granite, the inclusions have the closest resemblance to some local silurian fine-grained silicious rocks, and are not unlike some of the beds that occur in the stratified rocks close to the margin of the granite They are a little more metamorphosed than the latter, but that is all The sharp lines of lamination have been obliterated, but the direction of the grain can still be made out, under the microscope, without doubt or hesitation

In the case of the schists, the fine foliation is still unmistakably visible to the naked eye

One important fact about all the Dalhousie and Sutlej inclusions, except slices Nos 5 and 6, is that the changes which have been set up in them by contact metamorphism have not led to the formation of felspar

In nearly all my hand specimens and thin slices the junction of the granite and the inclusion is shown The granite maintains its characteristics up to the junction, and then there is a sharp transition to the slate, or to the schist, as the case may be In the slaty and the schistose portions of the slices felspar is absent

Another important distinction is that though the quartz and the schorl of the granite abound in liquid cavities with movable bubbles up to the line of junction, these liquid lacunæ are absent in all the inclusions examined, except Nos 7 and 8, No 7 being a highly-altered rock

These differences seem to me to be essential ones, and to be opposed to the acceptance of the segregation hypothesis as an explanation of these dark patches in the granite

In some respects the inclusions have yielded to the metamorphosing influence of the granite, and to this influence I attribute the presence of muscovite, crypto-crystalline mica, and schorl

A precisely similar metamorphosing influence was exercised by the granite on the adjoining stratified beds at Dalhousie, and in my paper on the microscopic structure of the latter (Records, XVI, p 141), I expressed the conviction that "the crypto-crystalline mica seen in contact with the granitoid rock is due to the injection of matter from the granitic rock into the schists in a gaseous or liquid condition" I also noted that, "though the gneissose granite is rich in felspar, only one small crystal of this mineral was found in the numerous slices of rocks in contact with the gneissose granite examined under the microscope"

This complete correspondence between the slaty and schistose stratified rocks in contact with the gneissose granite, and the inclusions in the main body of the granite itself, is a strong point, I think, in the chain of evidence which leads to the conclusion that most of the sharply-outlined dark patches which occur in the Dalhousie gneissose granite are really fragments of stratified rocks caught up and imbedded in it, and that the dark patches are not concretionary nodules due to the freaks of segregative action

Recently I have come across an inclusion at Dalhousie which, I think, sets the question completely at rest I found it in the gneissose granite near the top of Bakrota, about half a mile from the horizon of the stratified silurian rocks

One of my specimens has been very successfully photographed (about natural size) and reproduced as a print by the heliogravure process by Major Waterhouse in the office of the Surveyor-General to the Government of India, and forms the plate attached to this paper Nothing could be more perfect than the proof print now before me, it reproduces the exact appearance, and almost the very colour, of a piece of the Dalhousie gneissose granite

The inclusion represented in the plate is a section broken off from a long splinter of rock, shaped like a tent peg, included in the granite It is about two feet long, but I did not extract the whole of it, and cannot, consequently, say exactly how deep it penetrates into the granite The sections, chipped off one

after the other for me by a native stone mason, varied somewhat in size, but the three principal sides of one of these sections measured $2\frac{3}{4} \times 2\frac{1}{2} \times 2\frac{1}{8}$ inches

The splinter of schist must have been rendered partially plastic by heat, for the fragments show that when it was entire it was somewhat crooked in the direction of its length, and the lines of foliation (see plate) are considerably bent Thin sections of the specimen depicted in the plate are described under Nos 12-15

The rock is a very fine-grained schist An examination of the plate will show how fine are the lines of foliation

I do not think that any one, whose opinion is worth having, could examine the specimen itself, or even the plate attached to this paper, and believe that this finely foliated schist has originated in the granite itself by a process of segregation

Had the specimen been ground down to a uniformly flat surface, the contrast between the granite and the contained fragment of schist would probably have been even greater than it is in the plate, for whilst much of the dark marking of the granite is due to superficial discoloration, the broad lines seen in the schist, on the other hand, are lines of foliation These thin and thick lines of foliation run right through the splinter lengthways from top to bottom The gneissose granite is perfectly granitic up to the very edge of the splinter, and in fracture and structure there is no resemblance between the former and the schistose inclusion Moreover, as before remarked, whilst the gneissose granite is a highly felspathic rock, not a particle of felspar is present in the schist

I cannot myself for a moment believe that segregation could produce a highly silicious, finely *foliated* schist out of a highly felspathic granite, in which porphyritic crystals are to be seen meandering about in all directions up to the very edge of the schist If regard be also had to the long splinter-like shape of the schist, the improbability of such a result being produced by segregation is increased One might as well believe, it seems to me, that a fossil ammonite is a product of segregation

But perhaps some one who is disposed to assign a metamorphic origin for the gneissose granite, may affirm that the long splinter of schist is an undigested lump of the original rock from which the gneissose granite itself was formed Should any one be found to advocate this theory, I would ask where all the felspar in the gneissose granite came from? The gneissose granite at Dalhousie, it must be remembered, is a mass over six miles in thickness that extends in an easterly and south-easterly direction for some hundreds of miles without any diminution in thickness [1]

No felspar is found in the fragments of slate and schist embedded in the granite, and as the theory under consideration requires us to believe that these fragments were subjected to all the conditions to which the granite was subjected, the advocates of this theory will have to explain how lumps of foliated schist, or laminated slates, which were subjected to the aqueo-igneous agencies that reduced the main mass into a highly felspathic porphyritic granite, escaped being melted down and incorporated in the granite along with the rest of the sedimentary beds that supplied the material for the formation of that rock.

Is it to be believed that these lumps were subjected to all the influences that

[1] See map attached to the Manual of the Geology of India

prevailed to produce the extreme metamorphism of the highly felspathic porphyritic granite, and yet that no felspar was formed in them ?

The onus of explaining these difficulties rests on those who advance the theory under consideration, if there be any such, and until these difficulties are explained I think it would be mere waste of time to discuss this supposititious theory further

Those who have worked, even a little, with the blowpipe, know how powerfully a moderate amount of felspar acts as a flux on quartz, and in view of this fact, it seems to me almost self-evident that the schist would have lost its fine parallel foliation, and would have been melted down and incorporated in the highly-felspathic granite, had not the latter lost much of its heat, and had it not advanced considerably towards final consolidation, before the fragment of schist found its way into it

The past history of the inclusion cannot be the same as that of the granite The only explanation that satisfies my mind, and harmonises all the facts, is that the felspathic gneissose granite is an intruder in the rocks where we now find it, and the unfelspathic schistose inclusions are fragments of the rocks through which the granite passed on its way to its present position

Mr J Arthur Phillips, in his papers [1] on "Concretionary Patches and Fragments of other rocks contained in Granite," came to the conclusion that the inclusions contained in granites are of two distinct kinds "Those of the first class are the result of an abnormal arrangement of the minerals constituting the granite itself, whilst those belonging to the second represent fragments of other rocks enclosed within its mass"

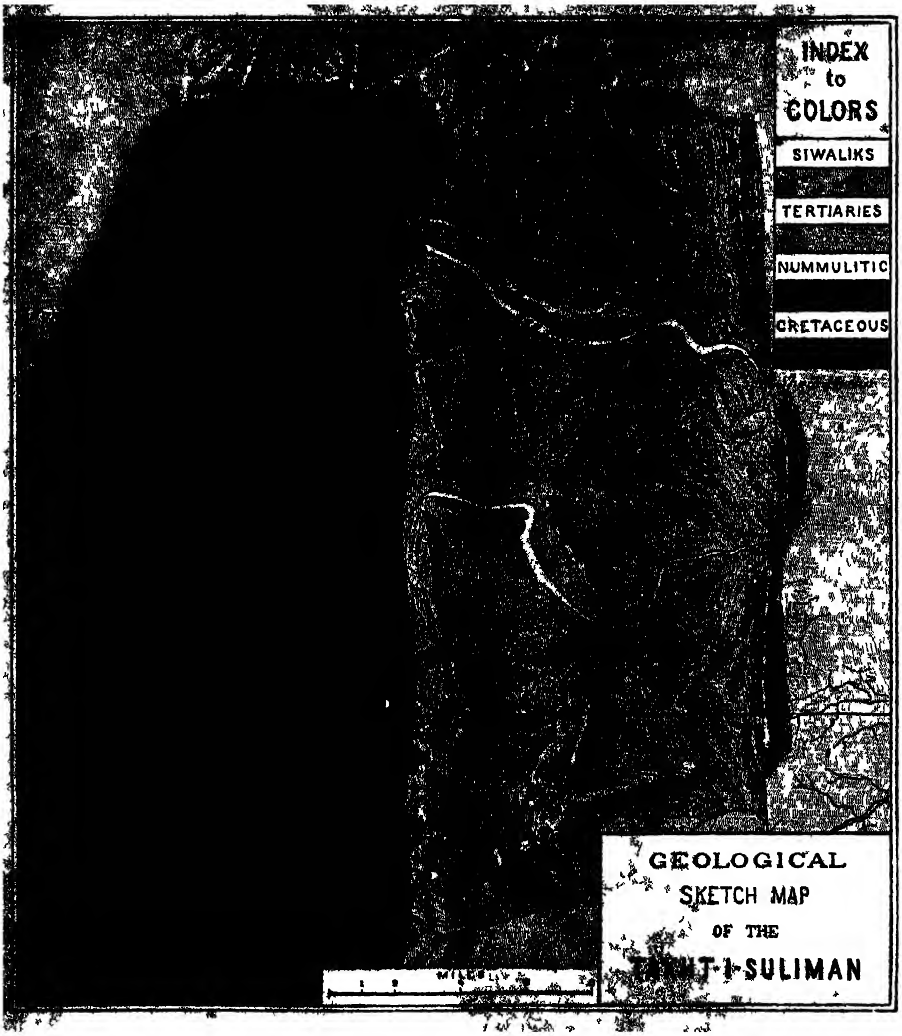
In the case of slices Nos 5 and 6 *(ante)* I was long in doubt whether these inclusions represent those of Mr Phillips' first or second class,—namely, whether they are nodules of segregation or are fragments of foreign rocks in a more advanced stage of metamorphism But it seems to me, on further consideration, that they are more probably the latter than the former

If it be granted that granites contain fragments of foreign rocks, it seems to me that we ought to expect to find these fragments in every stage of arrested fusion Fragments caught up before the granite had lost very much of its heat would surely be on the verge of digestion, and if the process of assimilation were to be arrested before its completion, the fragment would approximate closely in structure and composition to the granite itself

This hypothesis, it seems to me, accounts more naturally for most, if not for all, doubtful cases, than the theory of segregation

Even the case put by Mr Phillips, in his second paper, of large crystals of felspar growing out of the matrix into the inclusion, may, I think, be explained on the hypothesis above suggested All who have studied thin slices of rocks under the microscope must be familiar with the fact that felspars and other crystals grow, as it were, by successive additions to a central core, the successive zones of growth in sanidine, hornblende, augite, and other minerals, being distinctly visible under the microscope Dr Sorby has shown, in the case of quartz, that the additions to a crystal, or fragment of a crystal, made at a comparatively late epoch in its history,—as for instance, to grains of quartz in a sandstone,—

[1] Quar Journ G S, XXXV, p 1, and XXXVIII p 216


INDEX
to
COLORS
SIWALIKS
TERTIARIES
NUMMULITIC
CRETACEOUS
GEOLOGICAL
SKETCH MAP
OF THE
SULIMAN
MILES

are often in optical continuity with the portions upon which they form Supposing then, a felspar crystal in the matrix were in contact with the edge of an inclusion, I do not see why, in the event of the mineral matter contained in the inclusion being subjected to sufficient aqueo igneous heat to produce molecular freedom of action, the molecules of felspar contained in the inclusion, or introduced into it from the granite, should not be attracted by crystallographic molecular polarity to the felspar in the matrix, at the edge of the inclusion, and form on it Indeed, I think this would be very likely to happen, and the appearance of a felspar growing out of the matrix into the inclusion might be produced in this way, even in true fragments of foreign rocks imbedded in granite

Of course, this could only happen when the foreign fragment was imbedded in granite in a highly heated condition In the case of the long splinter of schist a fragment of which is depicted in the plate attached to this paper, it is clear that it must have been included in the granite when the latter was already partially consolidated, and had lost a considerable part of its heat

I have found on other grounds, in my previous papers, that the gneissose granite had partially consolidated before it was intruded into the stratified rocks, and the evidence afforded by the fragment of schist under consideration confirms this conclusion The schist would not have retained its fine foliation had the granite been in a fluid state, and at the high heat indicated by that condition

To conclude, I think the evidence available is sufficient to show that the majority of the Dalhousie inclusions are really fragments of foreign rocks imbedded in the gneissose granite, and if so, the further inference that the gneissose granite which contains them is an eruptive rock seems irresistible

The result of this independent investigation, therefore, is to strongly confirm the verdict on the gneissose granite arrived at on a consideration of other evidence

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Report on the Geology *of the* Takht-i-Suleman, *by* C L GRIESBACH, *Geological Survey of India* (With two plates)

Introduction

The following notes on the geology of the group of hills of which the Takht-i-Suleman is the culminating mass, nearly due west of Dera Ismail Khan, and situated in Afghanistan, were made by me during the progress of the expedition under General Kennedy, which in November last year was undertaken for the purpose of affording a survey party under Major Holdich, R E, an opportunity of conducting certain observations from the highest of the Takht peaks

I was attached to this expedition officially, but, as was natural under the circumstances, opportunities for a regular geological survey were limited, had it not been that the country traversed was very barren and thus very favourable for my work, even so much could not have been done as is here presented Although these notes and the accompanying sketch map are accordingly of a rough nature only, still I believe they give a fairly correct idea of the geological structure of this portion of the Suleman range,—a region which had never been visited by any geologist, or indeed by any European

The expedition started on the 15th November 1883 from Dera Ismail Khan, consisting of a brigade under Brigadier-General T G Kennedy, C B, the Survey of India was represented by Major Holdich, R E, whom I have to thank for the sketch map of the topography of the Takht region I was attached to the expedition by order of the Government of India, to conduct the geological survey of the area

Progress of the expedition

The route followed by the troops after arrival at Draband was by the pass known near its entrance as the Shekh Hydur Ascending the Zao stream, along

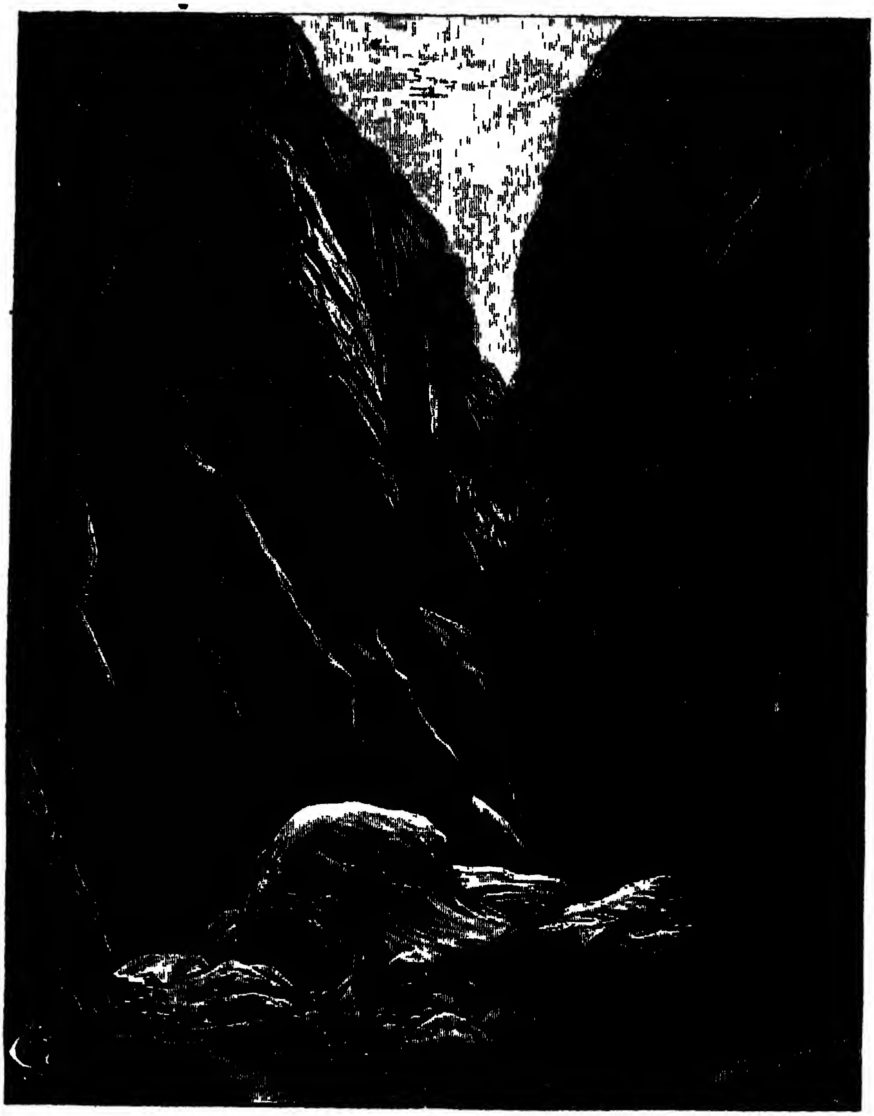


Fig 1 ' The Zao defile

its narrow defile (see fig 1) through the main range, we eventually crossed the divide between the Zao and Draband streams, north-west of the Kaisorghar ridge, and gained the Pazai Kotal, which forms an easy ascent to the Takht "Maidan," one of the routes used by the pilgrims to the holy shrine on the top of the Takht-i-Suleman The west slope of the Kaiserghar ridge is greatly denuded, forming extensive undercliffs with deep ravines and precipitous and high escarpments above The path beyond the Pazai Kotal leading up to the Maidan is along the crest of a buttress or neck left intact between two streams

Here our expedition met with considerable resistance, one of the sections of the Sheorani tribe, the Kidderzaies, strengthened no doubt by many of the unruly "budmashes" of these hills, prepared rude defences, on the rocky approaches to the "Maidan," and showed that they meant to contest our ascent It became necessary, therefore, to take the position by force of arms, which was effectually done on the 26th November, and the road to the "Maidan" cleared The final ascent of the highest peak of the group, the "Kaiserghar" (north peak), was effected on the 29th November by the survey party and myself, the escort being under command of Colonel MacLean, 1st Punjab Cavalry The return march was conducted along the same route

The very extensive and clear views which are obtained from a few of the high points (see profiles, Pl I and II) greatly aided me in tracing out the geological structure of the region, the country is very barren, and several of the beds hereafter to be described are easily distinguished owing to their characteristic bright colours

Previous observers

I am writing in the field away from the resources of a library, but I believe I am not wrong in saying that we knew nothing definite relating to the "Takht" geology itself, this region never having been visited by any European But a fair guess might have been made as several of the adjoining regions had been noticed by former travellers, and recently a sketch survey of the Suleman hills was completed up to the 30° 30′ latitude by Mr Blanford, late of the Geological Survey of India

Vigne, 1840 [1]
Fleming, 1853 [2]
Stewart, 1860 [3]
Verchere, 1867 [4]

None of the observers noted marginally actually traversed any portion of the area described by me Vigne went through the Gomal pass, but his notes hardly aid in elucidating the geology of the Takht

Fleming refers to a tract of the Suleman hills since described by Blanford

Dr Stewart's and also Dr Verchere's notes have no direct bearing on the Takht region, but the first mentions the occurrence of beds near Kanigoram, slaty with thin sandstones, apparently below the nummulitic series which may possibly be of lower cretaceous age, and perhaps identical with those west of the Takht

[1] Personal narrative of a visit to Ghazni, &c, Lond, 1840
[2] Quar Jour Geol Soc, Lond, Vol IX, p 346
[3] Jour As Soc Bengal, Vol XXIX p 314
[4] Ditto ditto, Vol XXXVI, pt 2, p 18

Mr V Ball, then of the Geological Survey of India, was the first professional geologist who traversed the Suleman range, and has given[1] a report of the geology of the range which he crossed by the Siri Pass west of Dera Ghazi Khan

Ball, 1874

The ground described by Ball has since been reported on by Mr Blanford,[2] and I will therefore content myself with noticing a few of the remarks made by the latter, as far as they bear upon the geology of the Suleman range only, his memoir contains criticisms of my work in the Bolan and Quetta neighbourhood, some of which no doubt are just enough, but to several of his remarks I would take exception, and hope to have an early opportunity of doing so According to his report, the physical features of the Suleman hills in latitude 30° 30′, up to which his report extends, seem much the same as those further north, where the Takht-i-Suleman forms the highest portion The main range consisting of one or more distinct ridges is skirted eastwards by low undulating hills mostly of tertiary age which are fringed by a well marked range of siwalik rocks along the margin of the Indus plain The following is Mr Blanford's list of formations —

Blanford, 1883

Systems or major divisions	Sub-divisions	Suleman	Geological age
5 Recent and post plio cene		Alluvium of Indus Valley Gravels of slopes, &c	Recent and post-pliocene
4 Siwalik or Manchhar	Upper	1 Conglomerates 2 Sandstones and clays, &c	Pliocene
	Lower	Sandstones, clays, &c	Upper Miocene
3 Nari	Upper	Sandstones, clays, &c	Miocene
2 Eocene	Upper	Olive clays, shales, sandstones, &c	Eocene
	Lower	Coarse brown sandstone	
1 Cretaceous		1 Hard whitish sandstone grit 2 Dark grey limestone passing down wards into limestone shales	Cretaceous

It will be seen from the following pages that the main divisions and beds described by Blanford have also been identified by me in the Takht region It will be apparent from my table on page 182 that, whilst some of Blanford's beds are wanting, there are several which seem peculiar to the Takht, unless it be that they are present in the hills west of Dera Ghazi Khan, but have not been recog-

[1] Rec G S I, Vol VII, p. 145
[2] Mem G S I, Vol XX, pt 2

nised by my colleague, he never having actually crossed the high range of the Suleman hills [1]

Physical features

The Takht-i-Suleman is here understood to be the group of peaks, which together form a more or less square block or *massif* amongst the neighbouring ridges It forms part of the long range known on our maps as the Suleman range, which in the area now visited has a due north and south strike (see Map) The drainage belongs to the Indus system, and the two valleys with which this report deals are those of the Zao and Draband [2] streams, both forming cross valleys through the main range, the first known as the Zao defile, and the second as the "Gut"

The general features of the ground are strikingly simple The high region consists of two principal masses, the Takht (with the Zao [3]) hills and the Shinghar (with the Karzbina [4]) forming the axis of the range and consisting of the oldest rocks of the area

The valleys of the Zao and the Draband rise between 3,000 and 4,000 feet above sea-level The defile of the Draband stream (the Gut) divides the range into the Zao hills (north) and the Kaiserghar or Takht hills (south) East of this range, and skirting it, is a belt of lower ranges, much denuded by the Suleman drainage, and which, roughly speaking, form a sort of trough, of which the Suleman hills form the western and the outer hills of Siwalik rocks the eastern rim. The latter form generally the boundary between India and Afghanistan

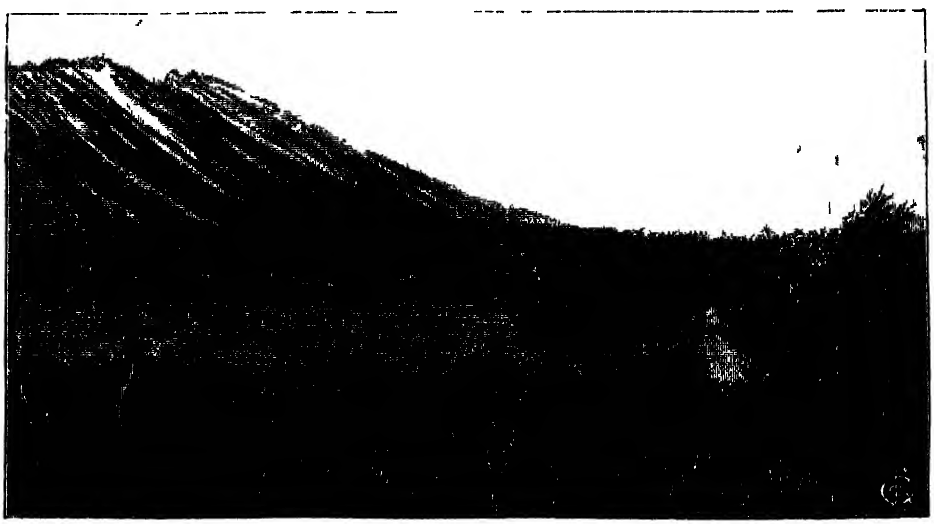


Fig 2 View of the 'Maidan' with the Kaiserghar

The massif of the Takht itself may be described as a high tableland (about 8,000 feet above sea-level) (fig 2) bounded on its east and west margins by high

[1] See page 123 of his report

[2] Major Holdich informs me that this stream is called the Lohar west of the "Gut"

[3] Zawa, Zawaghar of the map

[4] On the map Karajbina

rims formed by parallel ridges of rugged and steep outline The western ridge presents the highest peak (see fig 2) or Kaiserghar (11,300 feet), and the eastern culminates in the celebrated Takht-i-Suleman (see fig 3) 11,070 feet

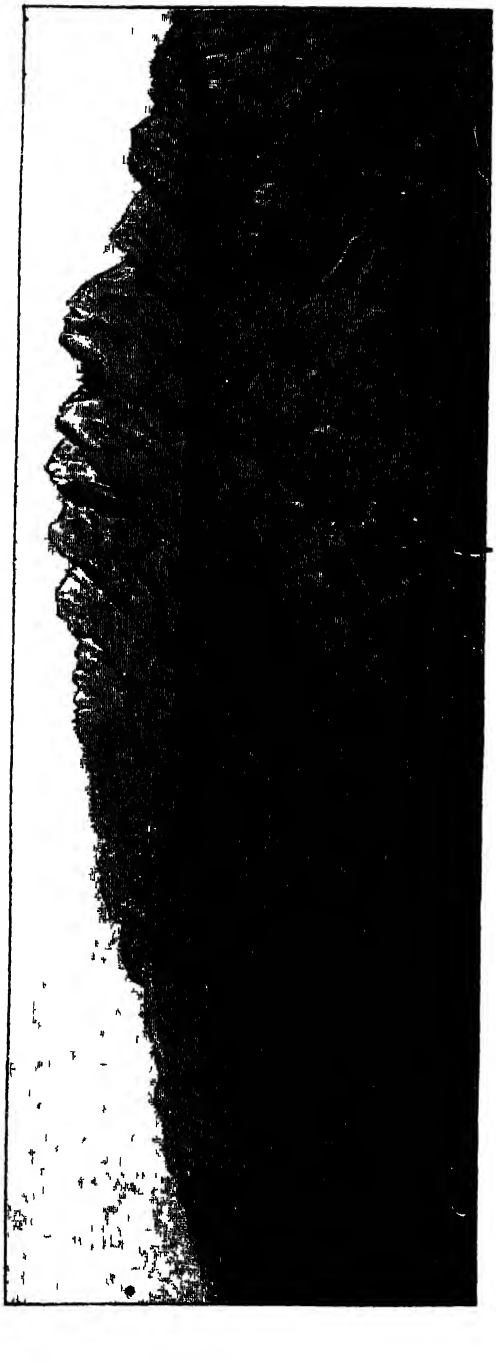


Fig 3 The Ts Suleman, Western pect

This tableland with its two parallel rims is altogether formed by a huge cap (if I may use the term) of coral limestone, to be presently described The entire Maidan and part of the slopes of the bounding ranges are covered by a fine forest of the *chilkosa* or edible pine The scenery is striking and fine, the forest-covered Maidan itself being quite park-like in its general appearance As might have been expected, water is only found in the deep ravines during the rainy season, when we ascended the hill, the only water obtainable on the ground was derived from the patches of snow lying in sheltered places of the Maidan and on the higher slope of the Kaiserghar

If ever this magnificent table mountain should be used for a settlement, water would have to be stored for the dry season, as has to be done in several similarly situated localities There is now the dry basin of a naturally formed tank on the Maidan, which could of course be enlarged and deepened.

The climate is magnificent, and in November was intensely cold in the mornings

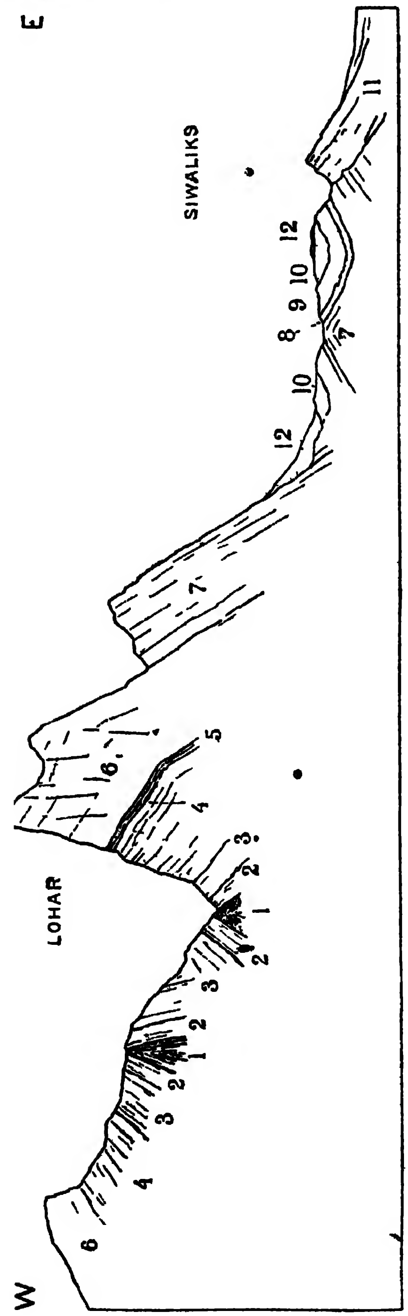
There is (I am told) an easy road leading to the Takht from Drazand, which is usually taken by the pilgrims coming from India

In the profile (b, Pl I) I have given a view over the

Maıdan from the top of the Kaıserghar which will ıllustrate the feature of the tableland with ıts two parallel ranges

Geologıcal results

I found the following formatıons and beds represented (see also fig 4) —



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Geological age	Sub divisions	Number in the section (see map)	DESCRIPTION OF ROCKS.
Recent and post pliocene	Recent	12	Sands and gravels of the Indus plain Gravels and fan deposits
Pliocene	Upper Siwaliks	11	Conglomerates and sandstone with clays
Miocene	Nari ?	10	Reddish brown to orange coloured sand stone, with bands of shales, grits, and clays, *fossils*
Eocene	Upper	9	Intensely bright coloured, red and olive green clays, with dividing beds of sand stone and sands, *fossils*
	Lower	8	Coarse brown sandstone and grits, *fossils* Black carbonaceous shales (locally at Gandera Kach)
		7	White limestone, *fossils*
Cretaceous	Upper	6	White and grey coral limestone
		5	Earthy shales
	Lower	4	Hard sandstone with limestone beds
		3	Coarse brown sandstone, *fossils*
		2	Grey shales with calcareous irregular beds, *fossils*
		1	Black and dark grey shales with lime stone partings and concretionary nodules

Detailed description of section

Two distinct areas

As mentioned before, the division of the ground into (1) the Suleman range and (2) the outer or fringing hills is striking in the extreme, and geologically the two areas are distinct, the Suleman range (where I crossed it) is formed entirely of rocks belonging to the cretaceous epoch, whereas the outer hills are all composed of tertiary and recent formations It will be easiest therefore to begin the description of the section[1] with the main range

1 *Suleman hills*

Cretaceous rocks of Suleman hills

That portion of the Suleman hills which I had the good fortune to visit, including under this name the parallel ranges of the Takht (with the Zao hills) and the Shinghar (with the Karzbina), is entirely made up, I believe, of the oldest rocks found in this part of the country The greater mass of the range or ranges is composed of cretaceous rocks, but it is quite possible that the lowest bed of the series shown in the table and section as bed (1) is of jurassic age

As will be seen from the figured section, the Suleman range is formed by one or perhaps more great folds of the cretaceous series When viewed from the east, *i e*, the Indian side, all that seems clear is that the beds have a dip due east, passing under the tertiary beds of the outer hills The short Zao defile, while exposing the rocks completely, affords little information as regards the structure

[1] In all cases where I refer to the "section" the ideal section is meant fig 4

of the range The rocks through which the defile cuts are greatly jointed, but it seems clear that the dip which is at first east becomes steeper, and eventually turns round to about 80° west Near the stone in the defile, known as the Sar-i-Sang (fig 5), the beds are raised up vertically or nearly so Water percolating through

Fig 5 The Sar i Sang in the Zao defile

open joints and between the bedding has here and there removed portions of the limestone beds, leaving caves, some of them of considerable extent At several points water issues in the form of springs out of openings between the jointed masses of the limestone beds One of these springs in the defile has a temperature of 74° and seems to contain some mineral in solution It is perhaps possible that the high temperature is owing to heat evolved by the decomposition of iron pyrites, common in the shaly layers between the lower cretaceous sandstones The dip becomes uniformly west on emerging from the defile, and remains so in the Shinghar range It was only after I had made two short excursions into the western parallel of the Suleman hills, one to the Karzbina, and another to the lower slopes of the Shinghar hills nearly opposite the Kaiserghar, that I could clearly make out the structure This is especially well seen in the Kotal Zawasir forming the divide between the Zao and Lohar (Draband) streams, and connecting the Shinghar with the Zao range The Kotal is shown in the profile Pl II, near the left side of the view

(1) Black shales

The anticlinal which forms the Kotal Zawasir is composed of the oldest rocks seen in the area When I say that they bear a strong resemblance to the Spiti shales of the Himalayas, most Indian geologists will recognise the character The shales are dark grey and black, crumbling in small fragments and splinters, with a few layers of limestone and traversed by numerous calcareous veins Here and there numbers of black concretionary nodules occur, but I have not found any fossils in them, nor in the dark shales It is this great resemblance to the jurassic Spiti shales of the Himalayas which makes me feel doubtful concerning the cretaceous age of these shales At all events they form the lowest beds in this range At the Kotal Zawasir (see section and Pl II) they form the centre of the anticlinal and are found nearly vertically raised up, dipping gradually both east and west They may be found, more or less, along the entire west side (left bank) of the Lohar valley

(2) Lavender grey shales, &c

Overlaying the dark shales, on both sides of the anticlinal axis, follow lavender grey coloured marly shales of very even texture, accompanying them are thin irregular beds of limestone, sandstone, and ferruginous shales, the exact succession and respective thicknesses I could not ascertain But on the whole I received an impression that the grey shales were the predominant feature of this sub-division In the ferruginous sandy shales I found some wretchedly preserved specimens of Ammonites, much crushed and in a state quite beyond specific identification They belonged to a species with strong transverse ribs

(3) Brown sand stones

Next in succession above these Ammonite beds come again on both sides of the anticlinal (3 in section) brown coarse sandstones and grits with ferruginous concretionary partings, the boundaries between the sandstone and the beds below and above them are not only not defined, but the beds evidently pass gradually from one into the other The thickness of the coarse sandstone is not great The upper beds become gradually fine-grained, even-bedded, mostly consisting of a whitish brown or speckled quartz sandstone, with an occasional calcareous bed intercalated, towards the top of this group the limestone beds become more and more frequent,

(4) Takht i Suleman sandstones

and then contain corals, which however are only seen on the worn surfaces of the limestone, being completely assimilated with the rock A few fragments of strongly ribbed Ammonites have been found by members of the expedition, but none of them would permit specific identification

This is probably the group also found by Mr Blanford to compose the greater mass of the main range of the Suleman hills west of Dera Ghazi Khan The thickness I can only guess to be not less than 800 to 1,000 feet As will be seen in my profiles Pl I a, and Pl II, and in the section fig 4, the lower half of the western slopes of the "Takht" and the Zao ranges and also the greater part of the eastern slope of the Shinghar range are formed of this characteristic sand stone formation In calling it such I do not wish it to be understood that it is by any means a homogeneous sandstone mass, on the contrary, towards the top especially, it becomes difficult to determine it either as sandstone or limestone, both being present The uppermost part of this sub division seems to contain more limestone beds than lower down

(5) Brown earthy beds of the Kotal

The sandstone group (4) is overlaid on the Takht i-Suleman side of the Lohar valley by a band of perhaps 50 to 100 feet of yellowish brown earthy beds with argillaceous shales and clayey beds I have not observed this band on the Shinghar and Karzbina side of the valley, but then the ground is less favourable for observation on that side, and I could not devote much time to that range Seen from the opposite side (from the west) the shaly band runs in a line from just above the Pazai Kotal to above the village of Niaz Kote, south west of the Kaiserghar (see Pl II) The bed is of considerable economic importance, as on it apparently collects all the water found in the Takht range during the dry season, the superimposed limestone permitting all the moisture to percolate through its joints and fissures The bed also marks a decided change in the rock formations The streams which supplied our camp with water at the Pazai Kotal and the springs above the village of Niaz Kote all issue from this horizon

(6) Coral limestone

Above this lower group of sandstones and shales I found huge masses of almost unstratified coral limestone of generally a light grey colour But dark grey masses of dolomitic character are not rare On the whole, it reminded me of some of the coral limestones of the Quetta neighbourhood, although the latter may possibly be somewhat older

The limestone is shown in the profiles of both plates (I and II), and in the section as (6) The appearance of this nearly unstratified mass of limestone, in which nothing but corals is observable, suggested to me the possibility of it being the remains of an ancient coral reef This idea would receive additional confirmation by the fact that the upper coral limestone is more or less of local nature only, from Blanford's researches it would appear that the uppermost bed of the cretaceous group of the Suleman hills west of Dera Ghazi Khan is the whitish sandstone, which may correspond with bed 4 of my section, always supposing that this want is not owing to denudation

Thickness and extent.

The thickness as seen on the Kaiserghar range may be at a rough estimate about 4,000 to 5,000 feet, if not more It composes more than the upper half of the Kaiserghar and the Zao ranges,

and, as might have been expected, the whole of the "Takht" owes its peculiar configuration to this solid cap of limestone It has (in the Kaiserghar range) an average dip of 20° to east Not only the "Maidan," but also the parallel ranges of the Kaiserghar and the Takht-i-Suleman are composed of this coral limestone The very top of the former I found of the same homogenous composition

The bedding of it on the Takht is seen to be very little inclined to the east, but beyond it the dip quickly becomes steeper, and the coral limestone may be seen to dip under the next higher group, which as far as I could judge from my point of observation, the Kaiserghar peak, seems to rest conformably on the Takht limestone

The crest of the Shinghar range appears also to be composed of the coral limestone (6)

The Karzbina point is composed of sandstone (4) (in fig 5), but the crest of the range further west is evidently composed of other rock forming a high escarpment in many places Blocks and debris of the coral limestone are also found in the ravines coming from the Shinghar range

(7) Nummulitic limestone

Outer hills—Blocks of limestone, mostly rolled and containing nummulites, were found along our line of march in the Zao, below Gandera Kach The rock had quite the concretionary appearance which is common to the nummulitic limestone of parts of the Bolan, and, as I have since found, of parts of the Salt-range [1] It is a light grey to white dense limestone, separating into concretionary masses, which feature gives it the appearance, from a distance, of a coarse conglomerate

I was not able to leave the road for any distance from our camp of Gandera Kach, near the entrance to the defile, and as the coral limestone of the Zao range is there quite exposed by denudation, and all the older tertiaries are removed or concealed by extensive gravel deposits, I never saw this nummulitic limestone actually *in situ* That is to say, I have not been able to lay hands on it, for it appears to me more than probable that the much denuded and steep hills which are seen to skirt the Takht and Zao ranges on the east are composed of this rock These skirting hills are so much a feature of the ground that they are easily recognised on the map, where as also in my profiles (Pl I, a and b) and in my section I have marked them as nummulitics

The tertiaries of the Zao and Draband valleys

As has already been explained, the area lying immediately east of the Takht-i-Suleman is a belt of lower undulating hills, about 12 miles broad, greatly denuded by the Zao and Draband drainage, and bounded on its eastern margin by somewhat higher and rugged hills belonging to the upper Siwaliks All this ground between the rugged hills marked as nummulitic limestone and the Siwalik outer hills, where not covered by recent gravel deposits, is composed of beds of limestones, clays, and sandstones with fossils, which in age range from the lower eocene to the miocene

Time did not permit of a more detailed examination of the area, nor were the opportunities and the state of the country favourable for such work All I could do was to separate on the map these tertiaries from the overlying

[1] As for instance north east of Musakheyl

siwaliks on one hand and the supposed fringing belt of nummulitic limestone on the other

Judging from the one line along which we traversed this area, it seems probable that the rocks composing it form several folds, which are much denuded and locally obscured by large deposits of gravels But the succession of beds, as nearly as could be ascertained, is as given in the table, page, 182 of this paper.

Doubtful horizon of certain tertiary lime stones

Below the clays and sandstones, which form the low undulating hill ground of the Zao and Draband rivers between the Takht range and the outer (Siwalik) hills, certain white and light grey bedded limestones crop up, which contrast markedly with the overlying deeply coloured clays They are flaggy and extremely hard, search in them revealed nothing but sections of Gasteropods and some doubtful fossils Nummulites I have not found in them, but their position below the undoubted eocene clays and sandstones of this ground, and also a certain resemblance lithologically with the nummulitic limestone boulders found there, would suggest that these bedded white limestones of the Zao belong to the uppermost portion of the nummulitic limestone (7) The sketchy nature of my reconnaisance of this valley has not permitted to distinguish these outcrops on the accompanying map of the ground.

Especially well exposed is it in the river bed between the camping grounds marked on the map as Guldad Kach and Gandera Kach, where it forms considerable cliffs on both sides of the river In position it is best seen just north of Guldad Kach, where the sandstone (8) and the clays (9) are seen to rest quite conformably on it There also the unconformity between this tertiary group and the upper siwaliks is very striking

It apparently is *in situ* in many places in the valleys formed by the Draband drainage, as can be seen from the Kaiserghar peak, from which a good view of the whole area was obtained (see b, Pl I) It seemingly forms a low escarpment facing the east (and the siwalik hills), behind which (westward) follow the intensely coloured rocks of the upper eocene formation

Near the entrance to the Draband valley in the fringing outer (siwalik) hills, the white limestone may be seen with its upper green and red beds dipping westwards and unconformably overlaid by the conglomerates and sandstones of the siwaliks

Conformity

Between this limestone (7) and the rocks marked (8), (9), and (10) in the section there is not a trace of the slightest unconformity, whereas the most marked discordance between this group and the younger siwaliks is observable The still younger gravels and fan deposits of the Zao are of course unconformable to both the older tertiaries and the siwaliks

(8) Sandstone, &c

The next higher beds are formed by dark brown coarse sandstones and grits, they are present in all the outcrops of the tertiary beds in the numerous streams about Guldad Kach, and are seen to underlie the olive and red clays (9) and to rest on the white limestone (7) Apparently it contains many fossils, and a larger collection might have been made had time permitted Nummulites, many bivalves (Pecten), and other ossils are found in great numbers

This sandstone is easily recognised and distinguished from the sandstones found at higher horizons The material of which the beds are made is evidently calcareous, and in places is nothing else but a breccia composed of limestone fragments and shells

It is very probable that this horizon is identical with the sandstone (lower eocene) described by Blanford [1] from the Suleman range

Black shales

Locally near the camping ground of Gandera Kach in the Zao valley, I noticed a bed of black carbonaceous shale intercalated between the sandstone (8) and the white limestone (7) There are partings of shaly sandstone in these friable black shales, and there seems no definite boundary between the latter and the coarse sandstone with Pecten, &c I have only noticed these shales at that part of the Zao valley, and it may be possible that it is a local development only The resemblance of the black shales with the coal bearing beds of Much in the Bolan is remarkable, I searched in consequence for coal seams, but found none I am told by Colonel MacLean, 1st Punjab Cavalry, that coal seams are found further south in the neighbourhood of the Dana pass, but it is not known in which horizon they are found

(9) Upper Eocene

There is a marked contrast between the coarse sandstone beds (8) and the overlying beds Without any appearance of gradual passage, there appear suddenly, in perfect conformity, olive green and densely Indian red clays, with only a slight indication of shaly bedding, but with partings of rusty brown sandstone They are very rich in fossils, in fact they appear more or less made up of foraminifera, bivalves and corals I am sorry to say that our daily marching prevented my making a good "bag" of them, but still the collection made will assist in defining their exact horizon when compared

I have little hesitation in identifying this clay group with the olive green clays of the upper eocene of the Suleman hills, described by Blanford.

The olive green and red clays occupy nearly all the slopes of the low hills forming the country immediately east of the Takht range Being soft and easily carried away by the rains, they are greatly denuded and traversed by deep ravines in every direction They are overlaid by the harder beds of the next succeeding horizon, and consequently the usual effect of denudation is visible, the clays and sands of the upper eocene are gradually removed by denudation and disintegration, whilst the more resisting sandstones of the higher beds slip after them The undercliff is therefore generally made up of blocks and slipped masses of the higher beds, whilst the latter form steep escarpments above the bright coloured clays (9)

From the high point Karzbina (see profile a, Pl I), I obtained a good view of some of the country forming the lower Zhob and Gomal valleys As far as I can form an opinion from such a distance, the tertiary beds and amongst them the bright coloured clays of the eocene series are largely represented in these valleys, at least bands resembling those seen in the lower Zao are seen to take part in the formation of the hills on the lower Zhob and Upper Gomal Some high hills south-west of the latter also seem to belong to the tertiary group A visit to this ground by a geologist ought to be extremely interesting

[1] Mem, G S I, Vol XX, Pt 2, p 35

Conformably resting on the bright coloured strata (9) of the upper eocene, I met a group of rocks, mostly sandstones of a bright reddish brown, weathering orange coloured, with subordinate beds of sandy shales and clays Some beds become locally grits and here and there are almost conglomeratic They are well seen in the nearly flat-topped hills north-west of Guldad Kach, where they form steep escarpments above the upper eocene In places they contain many fossils, mostly foraminifera and corals, but none in very favourable condition

(10) Miocene beds

I believe I may safely identify these beds with Blanford's Nari beds of the Suleman range, which he considers to be of miocene age

All these beds are of marine origin and are continuous in succession, not a trace of unconformity being traceable throughout, from the lower cretaceous of the Lohar valley to the miocene sandstones of Guldad Kach

The tertiary beds of the Zao and Draband valleys are seen to be overlaid unconformably by two distinct formations of gravels, conglomerates, sands, and sandstones

Siwaliks

The older formation of these two occurs, so far as I have observed, only in a more or less narrow belt, just fringing the marine tertiary zone east of the Takht, where it forms a high rim as it were or wall of broken and jagged outline So far as outward physical appearance goes, there is no difficulty whatever in at once identifying this fringing belt of hills with the Manchhars or Siwaliks of Biluchistan, which I have seen myself, and no doubt they are a continuation of the siwaliks of the hills west of Dera Ghazi Khan as described by Blanford

The beds composing these hills of siwalik rocks all dip to the east and are seen along the whole line of boundary to rest perfectly unconformably on and almost at right angles with the marine tertiary beds below This feature is especially well seen west of the gorge which the Zao stream has cut through these rocks, which is called the Shekh Hydur Pass, and may also plainly be observed in a similar position, near the Draband stream gorge, in these rocks a few miles south of the Shekh Hydur Pass

Apparently only the upper beds of the Manchhars or Siwaliks are represented in the sections east of the Takht, and of them only a small thickness (comparatively) is exposed With the exception of irregular and thick beds of a coarse brown sandstone, with gritty portions and a few clay beds, the whole group seems to be made up of coarse conglomerates of eocene and cretaceous limestones, cemented together by a sandy matrix Fossils I have none out of it Towards the Draband valley the zone seems to dwindle in width, the dip increasing and the beds disappearing beneath the alluvium of the Indus plain of Draband

Only Upper Siwaliks represented

Distinct from the conglomerates of the outer or siwalik zone are the very extensive deposits of gravels and sands, which I found to rest more or less horizontally on the marine beds of the Zao valley To distinguish these extensive deposits on the map was quite impossible, as the outlines of the overlying patches are doubtless very complicated and would require a closer examination than I could have devoted to this hostile district In general appearance they resemble the upper siwaliks as seen in the

Fan deposits

fringing belt, as far as I could form an opinion, angular fragments of rocks, some of very large size, are common in the gravels and conglomerates of the fan deposits Portions of the siwalik hills near the Shekh Hydur Pass are also overlaid unconformably by the more recent gravels, so that I believe myself to be right in separating them altogether from the former, as also from the recent alluvial beds of the Indus drainage

The gravels of the "fans" increase in thickness as we near the main range of the Takht, and where cut through by the streams (such as the Zao) the thickness of the gravel deposits is seen to be some 500 or 600 feet Towards the siwalik belt the thickness is reduced to a few feet

I believe the recent gravels belong to one or more huge fan deposits of an older drainage of the Suleman hills As the denudation went on in the softer rocks of the tertiary, no doubt new channels were cut and much of the fans again removed, and the gorges of the siwalik outer hills formed, leaving patches of the younger gravels high above the level of the present streams

Indus alluvium

Distinct from the fan deposits are the alluvial beds of the present streams, such as the boulder and gravel deposits and sands of the Zao and Draband streams and the fine silt and clayey sands of the Indus valley east of the hills of upper siwalik age

To this most recent formation of debris of course belong the taluses of the various ranges and the huge boulders which have caused so much trouble to the caravans passing through the narrow defiles of the Suleman range, such as, for instance, the Zao defile In some parts this defile seems filled with a confused mass of strange shaped limestone boulders, and at least one is a well known, and I might almost say, historic boulder, *i e*, the Sar-i-Sang (see fig 5) Others are denuded by the streams into strange shapes, such, for instance, as is shown in the view, fig 1

Their origin is simple enough, most of them belong to the dense grey coral limestone of the upper cretaceous group, the entire mass of which appears to be greatly jointed and separated into large solid masses The sides of the defile are almost vertical and therefore very little of the disintegration which must always take place would suffice to send huge intact blocks down the precipitous sides to be afterwards worn into various shapes by the tremendous rush of water which fills the defiles during the rainy seasons The Sar i-Sang has fallen into one of the narrowest parts of the defile, where it has jammed itself fast The river flowing round it has denuded it into a more or less round shape, whilst gradually its base became enveloped in silt and gravels

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Note on the Smooth-water Anchorages *of the* Travancore coast, *by* R D OLDHAM, A R S M, *Geological Survey of India*

On the Travancore coast there are certain spots where, in the height of the south-west monsoon, and on a coast exposed to its full force, ships can always anchor in smooth water These anchorages have long been known to mariners, and have at various times attracted attention In 1881 they were visited by Dr W King, Deputy Superintendent of the Geological Survey of India, who

found that the mud which formed the sea-bottom was not only greasy to the touch, but on analysis proved to contain an appreciable quantity of oil to which he attributed the smoothness of the water, this opinion has, however, been criticised by a writer in the *Madras Mail* (9th April last), who gave a totally different explanation, which I shall try to explain as briefly as possible

In the open sea the particles of water which form the waves move in approximately circular paths, each separate particle moving upwards, then forwards, and so round by a downward and backward motion to its original position, as long as the waves are in deep water they move forward as rollers, but the water itself does not move forward except so far as, it is forced forwards by the wind in a manner I shall explain afterwards

Now, if these waves come on to a shelving beach, the particles of water are not free to move backwards in the lower part of their course, but are restrained by friction on the beach, and the consequence is that those particles which are moving forwards in their course get ahead of the others, and the wave curls over and breaks But a solid shore is not necessary to make the waves break, for suppose it to be replaced by some liquid, like treacle or tar whose particles have not nearly the same freedom of motion as water, the lower part of the waves would be held back in the same way as by a solid shore, but to a less extent, so that the wave could travel further without breaking, but must break at last

The theory of the writer in the *Madras Mail* is this We know that during the monsoon large quantities of fresh water are poured off the land into the sea, that on these mud banks fresh water may sometimes be taken in alongside, that in any case the water at the surface is much fresher than sea water, and being in consequence lighter, floats out to sea on top of the heavier sea water Now, the difference between fresh water and salt is of the same in kind as that between water and treacle, though less in degree, the separate particles of salt water have not so great a freedom of motion as those of fresh water, and if, as is the case in these mud banks, the salt water is charged with fine mud, the difference is increased Let us suppose, then, that outside the anchorage is a strip of sea where there is a shallow layer of comparatively fresh water lying upon muddy salt water The great waves raised by the south-west monsoon roll into this, but immediately they reach it the bottom of the wave is held back on account of the less freedom of motion of the particles, i.e. the greater viscosity of the salt water, and, if only this layer of fresh water is broad enough, they will break and be destroyed In this way the absence of the larger waves from these anchorages might be explained But there is another class of waves which, in comparison with the first, might be called ripples, these are not large enough to follow at anything like the same rate as the wind, for the larger a wave the faster it travels, and in consequence the crests are often blown over by the wind It is to these that the small patches of foam are due which may be seen forming on the tops of the waves even in the open ocean, and which are often called "breakers" by landsmen, though their true nature is very different from that of the breakers formed on shore I have not any definite information as to whether these may or may not be seen on the anchorages, if they are not, it is most probably due to the oil in the mud, which, however, would hardly account for

the absence of the larger waves raised by the monsoon acting on hundreds of miles of sea

At present so little is known of the facts regarding these anchorages that no proper explanation can be given, and it is with a view to obtaining the necessary information that the following interrogatory is issued When the answers are collected we should be in a position to give the true explanation of these very peculiar and very interesting patches of smooth water

GENERAL

1 What experience have you had of the Western coast?

2 Are you personally acquainted with the smooth-water anchorages of Alleppy and Narrakal, if so, about how often have you anchored there?

3 Do you know of any other similar places on the Western coast where smooth water can be found during the south west monsoon? If so, what kind of bottom is found on them?

4 What is your experience near the mouths of rivers and other places where the surface of the sea is covered with fresh or brackish water during the monsoons? Do the waves in six fathoms of water and over generally run as large as in the open sea, or are they markedly smaller?

ALLEPPY AND NARRAKAL BANKS

5 Have you ever, during the south-west monsoon, known the sea over these banks to be salt—not merely brackish, but as salt as outside them? If so, was the water smooth or rough?

6 Of what size are the waves ordinarily seen during the south-west monsoon on the anchorages at Alleppy and Narrakal, and do they show broken water on their crests to any extent?

7 Have you ever noticed a film of oil on the surface of the water at Alleppy or Narrakal?

Notes on Auriferous Sands *of the* Subansiri River,—Pondicherry Lignite,—*and* Phosphatic Rocks at Mussooree *by* WILL KING, B A, D Sc, *Officiating Superintendent, Geological Survey of India*

1—Auriferous Sands *of the* Subansiri River

It has been long known that gold is obtainable in a small way from the sands of the Assam rivers, but fresh hopes regarding their productiveness have been raised through some reported rich washings On the 2nd June last the following telegraphic report was given in the *Englishman* of that date —

"DIBRUGARH, MAY 30

"Mr Scott Campbell, who has the monopoly of gold washing in North Lakhimpur, has received from Messrs King, Hamilton & Co the results of an analysis of some specimens of average washings from the Subansiri sands In 100 parts of washed sand decimal 161 of gold were found, being over twenty six ounces per ton Former rough tests by local goldsmiths gave about nine ounces per ton Specimens of Subansiri washings have also been sent to London for analysis The place whence washings were taken is well in British territory, below the Pithalibam

tea garden Unless the analysts' figures, as given by Messrs King, Hamilton & Co, are erroneous or the specimens unfair, the Subansiri sands must be the richest alluvial gold deposit known Mr Campbell guarantees the specimens analysed as average washings"

This is sufficiently startling in its suggestions of the richness of these sands, and a leading article on it, in the same paper, attracted the attention of the Government of India

Subsequent correspondence made me acquainted with the analyst, who wrote that he had based his calculation on the Assay Table in Mitchell's Manual of Assaying, which table is made out on the proportion that if 200 grains of *ore* give fine metal at such and such a rate, then one ton of *ore* will yield so much The proportion of 161 grains of the telegraphic account had, however, been obtained in 100 grains of the material, and by an oversight, the rate of over 26 ounces to the ton was given instead of double that amount, or 52 oz 11 dwts 20 grs

I have italicised the word "ore" in the last paragraph, because that word is used, in the Assay Table quoted, as a synonym for "mineral" or vein-stuff, and cannot for a moment be considered as applicable to *washed sand* Indeed, if the term ore is to be used, then the ore in the present case is the Subansiri sand, not the washed part of it It is this misuse of terms, and estimation on a particular filtering or sifting of a material known to contain gold dust, which invalidate the whole argument All that has been elucidated by Mr Campbell's find and the assay is that a minute quantity of washed sand gives a good percentage of gold, nothing is vouchsafed as to the amount of river sand which was treated for this residue, or of the time and labour consumed in that treatment

It appears, from previous observations, to be a fairly well established fact that the Subansiri sands have generally given the best yields among the many rivers of the Lakhimpur district which itself is one of the most favoured of the auriferous regions in Assam For instance, it is recorded that the average yield of the Subansiri river, about 1853, was from three to four pounds of gold for the year There is little doubt that improved methods of running such sands through cradles should make the out turn better than it ever has been under the crude manipulation of the native washer but that this will ever come near the anticipations of Mr Campbell is more than the indications of the rocks of the up land country, or the history of gold washing in Assam will allow At the very best, there may be spots in the great plain of the Brahmaputra which hold gold in some quantity, but the hitting off these is almost as chance a thing as can be conceived in so essentially precarious an occupation as gold prospecting

There is, moreover, some very suggestive evidence, adducible from actual outturns of gold from washed sands in the Lakhimpur district, as ascertained by Colonels Dalton and Hannay in 1855

" This gold was obtained partly in a Californian cradle washed by four men at Gurumora, 18 miles below Bhramakhund Two and a half tons of stuff which were passed through it yielded 30 grains, or in value Rs 2 8 In the native trough (or *duruni*), washed by three men, the yield from 18 cwt of stuff washed in one day was about 12 grains, or in value 1 rupee The natives looked upon this as a poor yieled, stating that after a flood they sometimes got double that amount."[1]

It is hardly necessary to point out that this very practical mode of testing the

[1] Manual of the Geology of India, Part III, p 225

auriferousness of the sands is of infinitely more value than any estimate based on an examination of a sample of concentrated washings

2 —Pondicherry Lignite

During the last two years various reports have appeared at odd times regarding an extensive and thick deposit of lignite occurring between Pondicherry and Cuddalore, which is to be compressed into bricks or patent fuel, and so help to relieve Madras from the reproach of having no coal or other mineral form of fuel within its proper borders

Mons Poilay, the Engineer of the Company which proposes to utilize this resource, was the discoverer of the deposit, and it is from this gentleman that I have personally and by letter, always received the most obliging information concerning its occurrence

Two thick beds of a dark brown or black deposit, some of which I would rather describe as a carbonaceous mud than a lignite, were struck during some of the artesian boring operations in the alluvial flat between Cuddalore and Pondicherry, though still in French territory Subsequent borings were carried out at Bávur or Bahour (French), Koniakovil, and Aranganur, three villages at the corners of an acute triangular area having its longest side, of about 5 miles, between Bávur and Koniakovil

The boring at Bávur pierced a bed of this carbonaceous deposit ("Lignite très noir avec pyrite de fer" of Mr Poilay's section) nearly 35 feet thick, at a depth of 275½ feet At Aranganur, nearly 2 miles north-north-east of Bavur, a similar deposit ("Lignite pur") over 27 feet thick was struck at 203 feet, and at 94 feet deeper another bed ("lignite") 5¼ feet in thickness This last would appear to correspond to a very thin streak at Bavur, some 30 feet below the thick seam at that place At Koniakovil, a little more than 5 miles north-east by north of Bavur, a 50 feet bed of "Lignite noir compacte" was met with at 330 feet

Other borings in the intermediate ground may have been made since the last bore sections (dated 20th October 1883) were supplied to me by my friend Mr Poilay, but I have received no further information on this point It is assumed that these three borings have struck the same thick bed, and that it may be fairly continuous over the triangular area at least, as a great bed among the alluvial deposits If all this be true and the deposit come up to the standard reported of it, then undoubtedly Mr Poilay's estimate of several hundred millions of tons of fuel is not exaggerated.

Some assays of the material do not, however, bear favourable comparison with those which were in the first instance made for the explorers by French chemists On the other hand, rather more promising but still unsatisfactory results have lately become public, through a report by the Officiating Chemical Examiner for the Bengal Government, to which reference will be made further on

The original assays, given in a preliminary notice by Mr Poilay, are sufficiently promising —

"The assay of a sample of this lignite, based on a report drawn up by M Philaire "Pharmacien de la Marine à Pondichery," dated 4th May 1882, gives by calcination, 6 per cent of ash, 49 per cent of volatile matter, and 45 per cent of coke, dullish black blistered, unequal fracture, friable, without woody texture

The elementary analysis gave the following result —

Carbon	59 9
Hydrogen	5 78
Oxygen and Azote	28 32
	94 00

"The calorific power of this combustible, as determined by M Philaire, is 4,182, with a density of 1 183"

Subsequent examination in Paris gave even better and presumably more reliable results thus, seven samples gave a mean of 8 35 of ash and 91 65 of volatile matters and coke

A comparison is then instituted between the Bavur deposit and the lignite of the Bouches de Rhone, in the following table —

	Bávur	Bouches de Rhone
Density	1 183	1 254
Nature of Coke	Intumesced	Pulverulent
Carbon	59 90	63 88
Hydrogen	5 78	4 58
Oxygen and Azote	28 32	18 11
Ash	6 00	13 43
	100 00	100 00
Hydrogen in excess	2 24	2 32
Calorific power	4182	5961

Our own trials of samples of this deposit gave very different results Mr Poilay very kindly intrusted several pounds weight of some to me, which he warned me was not as good as that of the proper thick bed and which was from the lower thin streak This was a nearly black, or brownish black, crumbly, slightly sandy carbonaceous mud which soiled the fingers I expressed my doubts as to the proper lignitic character of the material, but M Poilay seemed to have every confidence in the sample he was thus confiding to my care It was then submitted to my colleague, Mr F Mallet, in the Survey laboratory Some 20 to 25 lbs of the black mud were powdered and well mixed up, a sample of which gave the following composition —

Moisture	22 00
Volatile matter (exclusive of water)	23 90
Fixed Carbon	21 60
Ash	32 50
	100 00

Does not cake, ash light buff

A former analysis by Sub-Assistant Hira Lal gave—

Moisture	16 76
Volatile matter (exclusive of water)	26 66
Fixed Carbon	34 30
Ash	22 28
	100 00

Does not cake, ash reddish

A couple of months later, Mr Mallet wrote to me —

"Mr Daly, of the Bengal Pilot Service, lately brought up some more samples of the Pondicherry lignite, and some manufactured sub cylindrical bricks It is evident that the stuff varies very much in composition, as may be seen by comparing these analyses with those previously made"

	Lignite	Brick
Moisture	35 3	17 4
Volatile matter (exclusive of water)	29 1	25 6
Fixed Carbon	25 2	23 0
Ash	10 4	34 0
	100 0	100 0
	Does not cake, ash ochre yellow	Does not cake, ash buff white

This lignite is a black-brown hardened mud, with a few minute sandy particles scattered through it, carbonaceous

The latest examination of the Bavur lignite is that made by Mr Waddell, the Officiating Chemical Examiner for the Bengal Government,[1] and here again are some curious results, though they do come nearer the original assays put forward by M Poilay —

These specimens of lignite and patent fuel were submitted to Dr Waddell by the Public Works Department, Government of Bengal, namely —*Lignite in its normal condition*, *Lignite mixed with tar and allowed to dry in block*, and *Lignite macerated and mixed with water and allowed to dry in block* The "lignite in its normal condition" is described as of a jet black colour with a somewhat vitreous fracture and devoid of ligneous structure This is, of course, the form (normal condition) in which every one would first of all prefer examining the deposit, but I am bound to state that none of the material supplied to the Survey answers this description

Our specimens answer rather to the macerated lignite sent to Dr Waddell which "was of dark brown colour, dull fracture, thickly sewn with numerous white siliceous particles, dry to the feel, and readily crumbled under pressure" except that they were not so sandy or full of siliceous particles

So far, it seems very evident that a varied assortment of substances has been submitted for examination thus, samples from the upper seam, specimens from the lower bed, and manufactured bricks of kinds, as well as a macerated article which it is difficult to comprehend

[1] I first became aware of this report, by seeing it noticed in the *Madras Mail*, but my present information is from a copy supplied to me by the Revenue and Agricultural Department

I will now take the liberty of reproducing Dr Waddell's analyses, merely running his separate tables for calorific power and chemical composion into one —

Samples	No 1 Lignite, macerated and mixed with water and allowed to dry in block	No 2 Lignite mixed with tar and allowed to dry in block	No 3 Lignite in its natural condition.
Calorific effect	5047	6382	5318
Water	9 750	9 145	16 276
Volatile Hydro carbons	34 210	30 383	38 551
Coke { Carbon, fixed	23 090	29 402	37 720
Coke { Ash	32 950	31 067	7 451
TOTAL	100 000	99 997	99·998
LOSS		003	002

On the face of it, these substances are sufficiently incongruous in their condition, in their calorific power, and in their amount of ash It is not clear whether they have been procured from the same portion of the lignite bed indeed it is more clear that they have not been so selected and therefore they are hardly worth consideration as giving comparative values

On the whole, sample No 3, which has by all accounts remained free from treatment in any way, is the best fuel of the three, and I should not be at all surprised to find that it is a specimen from a band, or seam, or pocket, of more perfect lignite in the main thick bed The calorific power of this sample (No 3) is also comprehensible, but such is not the case with No 2 which with less fixed carbon and 23 per cent more of ash gives nearly 1,000 more units of heat Another very remarkable feature about all these assays is this, that when once an artificial brick is made, the ash increases enormously

In any case, samples (1) and (2) are very poor in spite of the calorific power attributed to them, and it is inconceivable how a locomotive or a steam-boat could be benefited by carrying about patent fuel containing 31 to 32 per cent of ash

The fact is, further and many assays and trials of average specimens of the lignite itself and the manufactured bricks must be made before any fair estimate can be arrived at of the capabilities of this deposit As far as I can see, the problems to be solved in the development of this industry, as indicated by the experiments now extant, are how to get rid of an enormous amount of ash and moisture, and how to consolidate the bricks by a medium the price of which shall not handicap the working of the deposit

3—Phosphatic Beds, Musuri

A very interesting discovery has been made at Musuri by the Rev J Parsons of Midlands, in which also Dr H Warth participated Nodular bands have been long known as occurring in the black shales of Musuri, but while Mr Parsons has been hammering among them for some years with the hope of finding fossils, and thus finding a more exact clue to the age of these rocks, he was struck by the marvellously bivalve like appearance of some of the nodules Indeed, the shape and even foraminal-like beak of some of them, give at first sight a remarkable semblance to certain terebratulidæ There, however, the likeness ceases, and the true nodular structure of the sub-ellipsoidal bodies soon becomes evident

It was next ascertained by Dr Warth that these nodules and a thin seam of rock associated with them contained a sensible amount of phosphoric acid

Mr Parsons then sent several parcels of the nodules to the Survey for examination, and a later supply of them, together with fragments of the rocky seam (supposed to be phosphorite) were sent on to us by the Revenue and Agricultural Department as from Dr Warth

The nodules present none of the characters of coprolites, they are merely concretionary forms of a nearly black or dark-grey colour, generally rough on the surface, but occasionally smooth and rather soapy to the feel, and rather hard They are only very slightly calcareous Some of them are not even phosphatic or only very slightly so, indeed, they are extremely varied in their constitution according to the greater or lesser amount of their components or the absence of one or other of them Taken in numbers, they are on the other hand essentially phosphatic, though not with lime phosphate

A preliminary assay of one by Mr Blyth, the Museum assistant, showed no trace of phosphorous but further trials of a few gave as much as 4 89 per cent of phosphoric acid

The so-called *phosphorite* occurs in thin seams associated with the nodules It is a nearly black, hard, somewhat vesicular (from the weathering out of ? sulphate of baryta) volcanic-looking rock, sprinkled through with small crystallisations of heavy spar The colour, and the harsh somewhat scabrous look, give the volcanic aspect, but the rock is really only a non-nodular part of the shale band It, too, has the varying constitution of the nodules, and may be called a phosphatic rock

The specimens were next submitted to my colleague, Mr E J Jones, who after a most careful series of experiments determined their composition as follows —

"Results of analysis of portions of eight nodules

Phosphate of Alumina
" " Lime
" " Magnesia
Silicate of Alumina
Sulphate of Baryta
Traces of Phosphate of Iron
" " Sulphide of Copper
Carbonaceous matter
Silica

Hydrofluoric Acid
and small quantities of Iron, Magnesia and Lime, not as phosphates

"Results of analysis of a rock supposed to be *phosphorite* —

Phosphate of Alumina
" " Lime
" " Magnesia
Silicate of Alumina
Sulphate of Baryta
Sulphide of Copper (traces)
Phosphate of Iron (traces)
Carbonaceous matter
Silica

and traces of Lime, Magnesia, and Iron, not as phosphates
Traces of carbonic and hydrofluoric acids

Thus the qualitative composition is the same for both substances, but I have thought it best to give each, as the latter was examined some time after the first

" Determination of phosphoric acid in the nodules —

45 17 per cent Phosphoric Acid
or 35 84 " " Anhydride

" Determination of phosphoric acid in the rock —

41 8 per cent Phosphoric Acid
or 32 3 " " Anhydride

" The most prevalent constituent in this form of shale is the phosphate of alumina.

A sample from five or six nodules, powdered, gives, according to Mr Blyth, 8 42 per cent of lime

In all true phosphatic nodules, or phosphorite, the essential constituent is phosphate of lime, though the "strength and value of the minerals is calculated according to the amount of phosphoric acid there is in combination with the other minerals [1]" There are only two cases recorded, namely the phosphatic deposits of Alta Vela, a small island near St Domingo, and Redonda Island (16° 54′ N, 62° 21′ W), which have little or no lime in their constitution In ordinary phosphates, the lime runs as high as 56 62, or only as low as 32 62 per cent while the phosphoric acid varies between 20 and 40 per cent

The Musuri phosphates might then be more properly distinguished as alumina phosphatic deposits The treatment of such phosphate is more difficult and complicated than that of ordinary calcareous phosphate, but can be effected (according to Spence's process) by solution in sulphuric acid and addition of ammonia from gas-liquor After the alumn has crystallized out the phosphoric acid in the mother liquor can be converted into artificial manure

From a geological point of view, this discovery by Messrs Parsons and Warth is particularly interesting as presenting indications of former life which may yet be more clearly displayed by the fossils themselves in the hitherto barren deposits of Musuri

[1] See a very elaborate article on Phosphate of Lime, in "Earthy and other Minerals and Mining," by D C Davies, 1884, Chap VII, Vol X

Mr. H B Foote's Work *at the* Billa Surgam Caves, *by* R Bruce Foote, F G S, *Deputy Superintendent, Geological Survey of India*

Introductory

Although the exploration of the Billa Surgam Caves was not very successful in its earlier stages, it has since then produced results of great interest, both archæologically and zoologically The existence of prehistoric man in that quarter has been most conclusively proved, while much light has been thrown upon the former geographical distribution of some important genera and species of animals no longer existing wild in the south of India. The deeper the excavations have been carried both vertically and laterally into the recesses of the caves the more interesting and valuable have been the finds made

A sketch of the first part of the exploratory work carried out by myself last year was given in the February number of the Records (Vol XVII, Pt I, 1884) At the beginning of the present year (1884), I was called off to other duties, but as His Excellency the Governor of Madras was anxious that the exploration work should not cease, it was entrusted to my son, Mr Henry B Foote, Lieutenant, Royal Artillery, who was temporarily attached to this Department, and took up the excavations where I had left off My son had spent several weeks with me a few months before, and had afforded me great assistance in exploring and excavating different caves, and had therefore gained a knowledge of the country and of the people whom he had to employ in the further explorations This he took up early in March, and carried it on till the end of May, during which time he cleared out the remaining half of the Charnel House Cave very nearly to the bottom of the narrow passage to which the cave contracts downward, a passage so narrow that the diggers have difficulty in finding room to work

Mr Henry Foote s work in the Charnel House Cave

In the Purgatory Cave

Mr Henry Foote also commenced excavating the Purgatory Cave, and was thereby enabled to follow it fully 300 feet further into the hill In a rough report of the work done by him, he says "I did not reach the end of this gallery as it was too narrow, but if it were cleared out, it would no doubt be possible to go much further in and also up several branches which were too much filled up to be entered"

When first explored, two pits were found in this long and narrow cave—one some 15—20 feet within its mouth, the other some 10 yards or so further in Nothing certain could be ascertained from the Kotal villagers as to the origin of these pits, which rumour ascribed to treasure hunters, but they were very likely sunk by guano diggers, the soil in the cave being largely made up of dry dusty guano derived from the droppings of the clouds of bats which live in the dark part of the passages On clearing the guano-soil out of the outer pit, Mr Henry Foote found its "further wall composed of a stalagmitic mass," of which he says "I fancied it might form a floor, and so continued the pit down to a depth of about 13 feet, when I reached the bottom of the cave, and found that my surmise was correct, there being a space of about 3 to 4 feet under the stalagmite filled with a red clay, with pieces of stalagmite and limestone forming a sort of breccia As

I had not much time at my disposal I could not then clear out the whole cave systematically, so I proceeded to clear out the earth under the stalagmite floor The floor continued for 9 yards and then gave way to the interstratified earth and bats' dung, and at this point I stopped. Among the finds in this cave were several fine teeth and a few bones I found also, just at the place I stopped at, two small drinking bowls of rough earthen-ware at a depth of 11 feet below the surface They are not of modern shape, but have no very distinctive character "

"As we advanced into the cave, the bats' dung stratum got thinner and disappeared altogether after 200 feet The cave earth is here a wet grey clay" "I fancy that the earth at the bottom (under the stalagmite) is of great age, and once filled the whole cave as in the recesses there are pieces of it adhering to the roof"

In the Cathedral Cave.

In the Cathedral Cave, Mr Henry Foote commenced systematic excavation about a month before the end of his time He reports "I could not at first work in it, owing to the numerous swarms of bees which occupied it, but after destroying their nests twice, they retired up the cliff to a safe height, and I commenced work in one corner of the cave, under an overhanging piece of the wall which, being the only place the sun does not reach in the afternoon, was the most suitable for human habitation "[1] "Having cleared away the bats' dung, which was about a yard thick, over a surface of about 50 square feet, I commenced to excavate the beautifully stratified cave earth in layers of one yard in thickness The top layer was very full of bats' dung which gradually disappeared as I got lower, when the earth became a rather stiff red clay " "There were a good many fallen blocks in places, but not so many as in the Charnel House There were also a good many masses of stalagmite, mostly on the edge of my excavation, all *in situ*, and as they were of large size the cave earth underneath them must be of considerable antiquity "

Stalactites and stalagmites.

The Cathedral Cave contains many more stalactites and stalagmites than any of the others, and a great part of its eastern end is filled with an enormous mass, composed of both forms of the deposit, to which the name of the "High Altar" was given from its great resemblance to the sanctuary in a Roman Catholic Cathedral It is impossible to give any closer idea of this remarkable cave without illustrations, which it is hoped will be forthcoming to accompany the final report on the cave work

Traces of prehistoric man

Cut bones

The existence of man at a low stage of civilization was ascertained beyond fear of contradiction by the discovery of a well-made bone gouge and of two pieces of stag-horn which have been cut with some sharp instrument, one indeed has been deeply cut into and shaped into a rude implement These were found in the Charnel House Cave at a depth of 15 and 16 feet below the surface respectively The Cathedral Cave also yielded an implement of bone trimmed by many cuts of a sharp instrument into a rude knife shape Two or three bones also were found show-

[1] The open exposure to the rays of the afternoon sun of a cave in the latitude of Billa Surgam would render the place practically untenantable for several hours The concentration of heat radiated from the high cliffs at the back and around the Cathedral Cave is something tremendous

ing distinct traces of having been scraped with a hard and sharp implement, the marks being such as would be made by a sharp stone flake

Number of bones found

A fair number of teeth and bones of various large and medium sized animals was collected, as well as many thousands of those of very small animals, such as squirrels, rats, mice, shrews and bats, also of small birds, snakes, lizards, frogs and toads Shells of some of the existing species of landshells were found numerously, particularly those of *Helix nicobarica*, *Nanina tranquebarica* and *Pleurostoma* (*nodifera ?*)

Difficulty about determining the bones

But little could be done towards the specific determination of the bones found, even where the genus was easily recognizable, the osteological collections available in Madras being far too small In the few cases in which specific determination was feasible, the bones were found to belong to living species

List of animals found

The annexed list gives, as far as possible at present, the generic and specific names of the animals whose remains were found in the Billa Surgam Caves —

MAMMALIA

Presbytis (*Semnopithecus*) *priamus ?*	*Equus*, sp
Macacus ? sp	*Sus indicus*
Chiroptera, several	*Rusa aristotelis*
Sorex, sp.	*Axis maculatus*
Felis tigris	*Memimna*
„ sp	*Antilope bezoartica ?*
Viverra zibetha ?	*Portax pictus*
Herpestes griseus ?	*Capra ?*
Canis, sp	*Ovis ?*
Sciurus, 2 or 3 sp	*Bos*, sp
Mus, 2 or 3 sp	*Gavæus ?*
Hystrix leucurus ?	
Lepus, sp	
Rhinoceros, sp (? *javanicus*)	

AVES

Several genera belonging to the orders Raptores and Grallatores (?)

REPTILIA

Crocodilus	*Agama*, sp
Varanus dracæna	*Lacerta*, sp

AMPHIBIA

Rana
Bufo

Condition of the bones.

The remains found all occurred as detached teeth and bones or portions of bones The best specimens are a few rami of mandibles and two or three maxillæ retaining four or five teeth a piece Most of the specimens, however fragmentary, are well preserved for

individual determination Few were thickly encrusted with kankar, few also were found in a state of great brittleness, but few also are highly mineralized The number of species already recognized is very large in proportion to the number of bones of the larger animals which were found, but it may be expected to be increased very considerably when the large series of small bones collected shall have been fully examined

Source whence the small bones were derived

The extremely great number of bones of small rodents, birds, reptiles, &c, &c, which were found in the different beds of the cave earth, may be reasonably attributed in great part to a cause which is still in action in these caves and adjoining ones The cause in question is the frequent visits of large birds of prey, such as eagles, kites, hawks, and owls who seek the quiet and retirement of the caves in order to get rid of the undigested hard parts of their prey, in the form of castings Considerable accumulations of such castings were found in the Charnel House and Cathedral Caves as well as in several of the smaller ones Osseous deposits of such character have doubtless often been covered up by the sediments brought into the caves by floods during wet seasons, the feathery and tendinous parts of the castings have decayed and only the bones remained behind

No signs of continuous residence of man or predatory animals

The evidence obtained so far goes to prove that the caves were not continuously inhabited either by man or predatory animals The greatest number of bones found in the Charnel House Cave, for example, occurred in, or close to, the mouth of the small tunnel-like gallery opening into the cave at its upper extremity These bones seem all to have been washed in from above by the stream which flowed out of this gallery in wet seasons, and which formed the several beds found in the upper end of the cave The beds which occur at the mouth of the cave and which were formed by the main stream flowing through the several cañons, are remarkable for their poverty in fossil remains How the bones entombed in the Cathedral Cave and in Purgatory reached their places of rest it would be premature to say till the excavations have proceeded considerably further

There are no accumulations of Album græcum in any of the caves, such as would inevitably have been formed had they ever been long occupied by carnivorous animals, nor are there any considerable deposits of ashes and charcoal with fragments of bones and other indications of man's continued residence which formed such interesting accumulations in many other bone-caves

No stone implements found

No stone implements of any kind have been discovered in connection with the Billa Surgam Caves, excepting perhaps a minute triangular splinter of rock crystal which might have served as a drill

Bitten and broken bones

Of the broken bones which occurred in considerable numbers some bear distinct tooth marks, others, and more especially fragments of the thick and massive bones of large animals, appear broken with great violence, as if with a hammer or heavy stone, not splintered, as if bitten

The great majority of bones whether unbroken or broken before being buried, as a very large number evidently were, retain their form distinctly and

show no signs of having been rolled far, which agrees with the inference that they were washed into the cave from only a very short distance

Of the crushed and broken bones which were found in all the three caves explored, many had been reduced to that condition by the falling of heavy masses of limestone from the roof No burnt bones were noticed in any of the caves

Occurrence of the genera Equus and Rhinoceros

A very interesting fact and one adding materially to our knowledge of the geographical distribution of the perissodactyle ungulata of India within the human period is the occurrence so far south in the Peninsula of the genus Equus and of a second species of Rhinoceros The living Indian representative of the first named genus is *Equus onager*, the wild ass of Kutch, which occurs also in Gujerat and the countries west of the great Indian desert, but is quite unknown in the peninsula Of the two Indian species of Rhinoceros now living, *Rh indicus* is reported by Lydekker[1] to have been procured from "the turbary of Madras" The remains of rhinoceros found by Mr Henry Foote belong to a smaller species with a very different dentition, being very markedly brachydont

The Billa Surgam Rhinoceros

The remains of rhinoceros found in the Charnel House Cave at Billa Surgam consist of a right upper molar (probably $\underline{\text{m } 1}$), a right lower molar (probably $\overline{\text{m } 1}$), and of a fragment of a right upper molar (probably $\underline{\text{m } 3}$) Of the first only the crown remains, but is in good condition The lower molar retains the greater part of the fangs, and the crown is in good condition (one little chip out of the anterior part excepted) The two were not found together, and the lower molar may probably have belonged to a larger individual than the upper The fragment of the upper molar ($\underline{\text{m } 3}$) must have belonged to a very much smaller individual than either of the others It shows but small signs of wear and could only have been cut a very short time before the death of its possessor The other two teeth are greatly worn and must have belonged to fully adult or old individuals

The upper molar is very characteristic in shape, and quite unlike any of the fossil Asiatic rhinoceroses already described It is also quite unlike the molars of *Rhinoceros indicus*, but bears considerable resemblance to the molar of *Rh sondaicus* (*javanicus*) figured by Owen in plate 138 of his Odontography

The Billa Surgam horse

The remains of Equus found were the following —

1	A molar (lower, left)	Charnel House Cave	
2	A metatarsal right	Cathedral Cave.	
3	A rudimentary metatarsal (Met. IV)[2]	do	do
4	A metatarsal (?) distal end	do	do
5	Three incisors, germs (upper ?)	do	do

Of these, numbers 1, 2, 3, and 5 belong to a small individual, of about the size of an ordinary ass No 4 belongs to a much larger, coarser built, animal

[1] Lydekker, R Synopsis of the fossil Vertebrata of India, Records, Geological Survey of India, Vol XVI, p. 80, 1884.

[2] This rudimentary (left) metatarsal belongs doubtless to No. 2, as though found several feet apart in the cave earth (in squares Nos 41Ca and 45Ca respectively) the two bones fit perfectly and show identical colour and degree of fossilization

Section of the Cave Earth, Charnel House Cave

The section of the cave earth in the Charnel House Cave which was obtained by Mr Henry Foote while excavating the northern half was much clearer and more instructive than that seen by me in the southern half, the former is therefore given below —

4′	A^1	Surface (bats' dung) bed	3′
2′ 9″	A	Rubble bed with large fallen blocks of limestone	2′ 9″
3′ 6″	B, C	Stiff red clay, with sandy partings[1]	4′
2′ 6″	D, E	Rubble bed	1′ 6″
3″, 9″	H	Red cave earth, stony above	6″, 6″
1′ 3″	I	Red and mottled cave earth	1′
	J	Red brown cave earth with patches of calcareous sand	1′
	K, L	Red sandy cave earth with blocks of limestone	1′ 6″, 1
	M, N, O, P	Stiff marly clay taken out in four layers of 1 yard each in thickness	12′
			28′ 9″

The section is across the cave, rather to the westward of the centre, and runs in a nearly north south line The depth and nature of the deposits below P are still unknown

" The stratification of the cave earth, though very distinct in places, was more often obscure, and the large amount of infiltrated colouring matters (though often giving rise to very beautiful tints) were a source of great difficulty in the separation of one bed from that underneath it "

Contents of surface bed

The artificial contents of the surface bed were, as already stated[2] a few bits of broken pottery and charcoal, and a couple of small chank shells, doubtless once the property of some gossain or fakir In addition to these were patches of small bones, &c, which are the half-weathered castings of large birds of prey before referred to (page 203) A full collection of these was made for comparison with the numerous bones of small animals which Newbold described as occurring in the cave earth below

Human bones and teeth below the surface bed

The loose red loam underlying the surface bed contained at one place (21 feet west of the entrance to the narrow passage at the east extremity of the cave), a number of human teeth and bones, belonging apparently to one and the same individual The bones consisted of numerous fragments of a very thick calvarium (too broken to piece together successfully), fragments of the mandible and one or two vertebræ, ribs and parts of various limb bones[3] They had been much broken up by a large mass of limestone which had fallen on the spot where they were buried, and being very brittle suffered a good deal more while being dug out

[1] The Rubble bed " A " occupied only the front or western half of the cave, in the back or eastern half, " B " lays immediately under the surface bed " A^1 "

[2] Rough notes on Billa Surgam and other caves in Kurnool District, &c Rec G S of I, Vol XVII, pt 1, page 27, 1884.

[3] These have not been compared as yet.

The most interesting facts connected with the underlying strata in the Charnel House may be briefly enumerated at this place Bed "A" yielded *inter alia* the right ramus of the mandible of a very young small ruminant (? *Antilope*), also the right maxilla with teeth of large monkey, differing slightly from *Presbytis* (*Semnopithecus*) *priamus* From the relatively small size of the canine the owner was probably a female, but her jaws exceeded considerably in size that of a very fine male langur whose skull is in my collection

Finds in bed A

In Bed $\frac{B}{C}$, Mr Henry Foote found some charcoal and fragments of coarse unglazed pottery, as well as fragments of thin glazed red pottery of a very antique type

In bed $\frac{B}{C}$

Bed $\frac{D}{E}$ showed nothing of interest, and beds F and G, which lie further back in the cave and do not come within the section above given, were also devoid of anything of special interest

In bed H, there was at one spot an immense quantity of small bones of rats, bats, lizards, &c, &c, accumulated either by an eddy in the small stream, which flowed through the eastern passage, or else representing one of the great collections of birds' castings above referred to

In bed H

In bed K, Mr Henry Foote found the bone gouge above referred to "the best specimen of man's work that was found in the caves" "The hollow of the gouge is highly polished probably by use" "The cutting edge is gone, but the other edges show distinct marks of having been cut with a sharp instrument It was found on the north side of the cave, about 4 yards from the mouth of the small passage, at a total depth of 15 feet below the surface"

Bone gouge in bed K

Of bed L, Mr Henry Foote says "it contained a little charcoal at the mouth of the small passage, this being the lowest horizon at which I found traces of man, the depth being 16 feet 6 inches Associated with the charcoal, I found two pieces of stag-horns, which present distinctly cut surfaces" The one, as already pointed out, is cut into something little a rude knife about 5 inches long, or it might possibly have been used as a small spear head if the but-end had been fixed vertically at the end of a pole The other piece, which is 6¾ inches long and much thicker and heavier, has the further end distinctly cut on two sides, so that it forms a short but thick wedge The whole piece looking like a rather rude pick-hammer The cuttings are very clear and distinct on both implements Bed L was the most prolific in large bones of any in the Charnel House Among those found, it may be well to specialize a few of the most important

Cut stag horns in bed L

1 The left ramus of the mandible of *Portax pictus*, fragment with 4 teeth (No 7, 70 L)
2. Molar 3 (lower) of *P pictus* (No 9)
3 Five incisors (lower) of *P pictus* (No 12)
4 Carnassial (lower) left of *Viverra zibetha* ? (No. 16)
5 Lower left incisor $\overline{2}$ of *Antilope bezoartica*
6 Cervical vertebra of *Portax pictus* ? (No. 56).

7 Olecranon (broken) of *Axis maculatus*? (No 57)
8 Left scapula of *A maculatus*? (No 64)
9 Right scapula of *Rusa aristotelis* (No 68)
10 Left tibia of *Axis maculatus*? (No 32)
11 Right tibia (distal end) of *A maculatus*? (No 37)
12 Left calcaneum of ditto (No 31)
13 Right femur of ditto (No 33)
14 Metacarpal of ditto (No 43)
15 Right tibia (distal end) of *Rusa aristotelis*? (No 36)
16 Left astragalus of ditto ? (No 30)
17 Phalanx of *Capra*? (No 1)

In bed M bones of monkey

Bed M was also productive of bones and, in a recess in the side of the small passage at its bend, some remains of a large monkey were found consisting of a right maxilla with 3 molars and 2 premolars, the right ramus of the mandible with 3 molars and 1 premolar, also a fragment of a left ramus with the canine and 1 premolar, and lastly a lower left molar ($\overline{M\ 2}$) All apparently belonged to the same individual

The other important bones found in bed M were—

1 Os innominatum (right) of *Rusa*
2 Ditto (do) of *Axis*
3. Femur (right) of *Antilope*
4. Metatarsal (right) of *Axis*?
5 Vertebra of a snake

Beds in the passage

The excavation of the beds in the inner-most part of the small passage was carried out by Mr Henry Foote separately, as he found it impossible to make out their exact relation to the several beds of the cave earth in the outer cave The cave earth beneath the surface (bats' dung) layer was red and so nearly homogeneous in character, owing to the absence of infiltrations of colour, that the division into layers for excavations must be considered a purely arbitrary one The four divisions in which it was taken out were termed X, Y, Z, and X 1, of which Y yielded a small crocodile's tooth much blackened in colour, and X 1 the rather broken crown of a very large left lower premolar of some ruminant which was most likely that of a bison (Gavæus)

Finds in Purgatory Cave

The most interesting bones Mr Henry Foote obtained from the Purgatory Cave were as follows —

1 The right upper carnassial tooth of a feline animal smaller than a tiger

2 The right metatarsal bone of a large tiger (*Felis tigris*) of which the proximal end and the under side are wanting but the bone otherwise in good condition

3 The right tibia of a large tiger, the proximal end wanting

4 & 5 Two phalanges (right) of pes of *Felis tigris* Besides these were seven or eight molars of different ruminants, large and small, which could not be satisfactorily determined

Finds in the Cathedral Cave

In the case of the Cathedral Cave the most important finds made by Mr Henry Foote beside the Rhinoceros teeth and the teeth and bones of Equus above referred to (page 204) were—

1 A series of bones of *Hystrix* (*leucurus*), consisting of two mandibles and sundry molars and incisors belonging to several individuals [1]

2 Two upper molars, four lower incisors, and two lower canines of *sus indicus*

3 A series of bones of *Varanus*, including 3 maxillæ and 3 left rami of mandible and many vertebræ

4 A series of bones of birds of several genera

Conclusions as to the age of the caves

The determination of the animal remains found in the Billa Surgam Caves, so far as has been practicable, shows that the very great majority, if not all the larger animals, belonged to living species, they must therefore be regarded as of pre-historic or post-pleistocene age This result is in accordance with the evidence furnished by the bone implements found in the caves, which implements bear a very close resemblance to finds made in various pre-historic bone-caves in Europe The stone implements, accompanying the European bone implements, belong to the neolithic, or polished, type, we may therefore very reasonably expect that, should stone implements be discovered during the further explorations, they will prove to be of the neolithic type But we may also very reasonably anticipate that in some of the caves only partially explored at present, or in some of those still untouched, future explorations may bring to light remains of palæolithic man and pleistocene animals, for it must be borne in mind that palæolithic man lived in that region and left numerous implements behind him in the adjacent alluvium of the Khunder valley

The results now communicated may, I believe, be accepted unhesitatingly, as very great care was taken both by my son and myself to register exactly the positions in which the bones were found

I re-visited the caves in the beginning of May to see how the exploration was progressing, and was much gratified to find that Mr Henry Foote had organized his band of excavators very thoroughly, so that the work proceeded steadily and safely

The efficient way in which he carried out the very arduous piece of work confided to him fully justified the confidence with which I had recommended him to His Excellency Mr Grant Duff, and will I trust be recognized by the authorities

In conclusion, I must mention that our work at the caves was rendered much less irksome by the great interest taken in it by His Excellency Mr Grant Duff Our thanks are also due to Mr W H Glenny, the Collector of Kurnool, for the kindly interest he took in the work throughout which greatly helped to make things easy in the matter of securing supplies and labour in a very outlandish place Nor do we forget various acts of courtesy and kindness from the Nawab Sahib of Banaganpalli

[1] Up to the time of the excavation porcupines were constantly trying to colonise the caves, and were only repressed by the use of traps built by the villagers of pieces of limestone As it was, a couple of them was caught and killed by the diggers in one of the pits in Purgatory Cave

ADDITIONS TO THE MUSEUM

FROM 1ST JULY TO 30TH SEPTEMBER 1884

Specimens of garnets (Spessartite ?) and of the mica schist in which they occur, from Kulu
PRESENTED BY COL G GORDON YOUNG, COMMISSIONER, DHARMSALA, PUNJAB.

A large piece of Pumice, picked up at Sea, Lat 80°S, Lon 83°E, on 30th November 1883.
PRESENTED BY CAPT HENRY MAYO

A specimen of stibnite (antimony glance), and a button of metallic antimony reduced from cervantite, an ore of antimony, ($SbO_2 = Sb_2O_3 + Sb_2O_5$), from Maulmain, Burma.
PRESENTED BY W R CRIPER, ESQ.

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